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ANCIENT EGYPTIAN ASTRONOMY: TIMEKEEPING AND COSMOGRAPHY IN THE NEW KINGDOM

Submitted for the Degree of Doctor of Philosophy
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1999

Abstract

The first part of this study analyses and discusses astronomical timekeeping methods used in the New Kingdom. Diagonal star clocks are examined first, looking at classification of sources, decan lists, and the updating of the tables over time. The date list in the Osireion at Abydos is discussed, and issues concerning its place in the history of astronomical timekeeping are raised. The final stellar timekeeping method, the Ramesside star clock, is then examined. The conventional interpretation of the observational method behind the tables is challenged by a new theory, and a system of analysing the tables is introduced. The conclusions of the previous sections are then gathered together in a discussion of the development of stellar timekeeping methods.

The small instruments known as shadow clocks, and their later relatives the sloping sundials, are also examined. The established hypothesis that the shadow clock was completed by the addition of a crossbar is challenged and refuted.

The second part of this study is based on New Kingdom representations of the sky. Two major texts and several celestial diagrams are discussed in detail, beginning with the *Book of Nut*, which describes the motions of the sun and stars. New translations of the vignette and dramatic text are presented and discussed. Portions of the *Book of the Day* describing the behaviour of the sun and circumpolar group of stars are analysed.

Finally, celestial diagrams dating from the New Kingdom are described. Their composition and significance is discussed and the conceptual framework behind the diagrams is recreated.

By introducing new theories and analysis methods, and using a modern but sympathetic approach to the original sources, this study attempts to update and extend our knowledge of these areas of ancient astronomy.

ACKNOWLEDGEMENTS

I wish to express my deepest gratitude for the help, guidance, and support I have received throughout my research from my supervisor, Dr Michael Dampier.

I also wish to thank Dr Mark Collier, Fellow of All Souls College, Oxford, for teaching me so much about Egyptian grammar and nuance, and for his advice concerning the texts translated within this study; and Dr Allan Mills of the Astronomy Group, University of Leicester, for his interest and support for my work.

My study was supported by a University of Leicester Studentship.

CONTENTS

INTRODUCTION

The study of astronomy in Ancient Egypt has traditionally fallen between the fields of Egyptology, astronomy, archaeoastronomy, and history of science. Researchers from all four disciplines have looked at the area from different perspectives. In addition however, there have been reasons why researchers have not tackled the field: Egyptologists have felt it required too much technical knowledge while other researchers have believed that those capable of reading the texts are most suited to studying the material. Also, many feel that the Egyptians did not reach a high enough level of scientific knowledge, nor develop rigorous enough methods of observation and recording, to make the study interesting or valuable, while others have felt that the subject is too strongly linked to the Egyptian religion for a scientist to work on comfortably.

These reasons are now being discarded: Egyptology has become more tolerant to multi-disciplinary approaches, and the traditional labelling of anything non-classical as 'primitive' has to a large extent disappeared.

This study tackles the subject with, it is hoped, a mixture of the scientific and the Egyptological, the analytical and the sympathetic, and aims to examine some existing theories, present new hypotheses and introduce new ideas into this interesting and somewhat neglected area.

The term 'astronomy' means 'the scientific study of celestial objects, of space, and of the physical universe as a whole' (Concise Oxford Dictionary). Throughout Egyptian religious literature we find a plethora of celestial references. We find depictions of the sky on the ceilings of temples and tombs. We find written predictions and records of certain astronomical events and we find evidence that celestial references were used for architectural and timekeeping purposes.

The Egyptian use of celestial objects differs from our own. We have devised a series of specialised disciplines to study various aspects of the sky. In our every-day lives, celestial bodies play only a very small role. The presence or absence of daylight is the most noticeable intrusion of the celestial realm. Those living or working with the sea are also affected by the tides, which we now know are caused by the gravitational effects of the moon. Apart from admiring a clear night sky, this is as close as the majority of present-day westerners come to the cosmos. The serious study of such things is left to scientists, of which we have many different kinds: astronomers, astrophysicists, space scientists, cosmologists, meteorologists etc. In other words, we have drawn strict dividing lines and have developed a taxonomy in which to fit the universe and the study of the universe.

The ancient Egyptian view of the sky appears to be somewhat different. We cannot know what the Egyptian worker thought when he looked up at the sky, but information has survived which shows us a little of how the educated priest may have perceived the heavens. We find that the line between the physical and the spiritual is difficult to draw: the priest would look at visible points of light, but would see spirits and gods. He would describe their motions in terms of spiritual journeys and explain their existence in terms of myth.

One of the exciting aspects of reading religious texts which describe celestial objects is that, unlike most spiritual literature from ancient Egypt, we can still see the objects to which the texts refer. Although the effects of precession have altered the orientation of the sky, we can calculate what the heavens would have looked like thousands of years ago. The celestial bodies themselves are still there and still behave exactly as they did then. Unlike ancient cities, or events, or characters whose location, significance, and appearance are lost to us, the sky remains. What has changed, however, is our human perception of it.

It is unfortunate that a study such as this should have to begin by drawing limits around what is and what is not 'scientific study of celestial objects'. In itself, the act of dividing suppresses some potential for further understanding. However, the choice has been made to concentrate on two linked areas: timekeeping and cosmography.

'Timekeeping' is easily defined: using celestial bodies to mark periods of time. Previous research into the area has defined a small number of distinct methods which the Egyptians developed for this purpose. Texts dealing with these methods are readily identified by their contents, but are rare.

We shall discuss five timekeeping methods, three based on the stars and two on the sun. Other timekeeping devices which do not have an astronomical basis (such as burning wicks and water-clocks) will be mentioned but are not within the remit of this study and will not be dealt with extensively.

'Cosmography', 'a description or mapping of general features of the universe' (Concise Oxford Dictionary), however, is a far more difficult area to define. Clearly, the celestial diagrams found on ceilings in temples and tombs fall into this subject area. Further texts were chosen which by style, location, and primarily by content, indicated that they were related to the celestial diagrams. This study has been limited to this small selection. To open the study to celestial references within the wider corpus of Egyptian religious literature would have been a massive undertaking, and the relationship between the two subjects, timekeeping and cosmography, would have been obscured.

Cosmography is an area distinct from cosmology, both in the modern scientific sense and in the Egyptological sense of a creation myth. Cosmography in essence deals with a state rather than a process. This distinction is slightly clouded by the Egyptian belief that even repetitive events, such as the motion of the sun, must have cause at each occurrence. We therefore find similarities between a 'cosmology' describing the creation of the universe by a god, and a 'cosmography' which describes the annual journey of a star (for example, the similar imagery between a creation myth as related in the cosmological text *The Book of the Divine Cow* and the description of the motions of the sun and the stars in the cosmographical text *The Book of Nut*). Egyptian cosmologies fall within the scope of theological studies and have no conceptual link with modern scientific cosmology, whereas cosmographical texts contain concepts which we recognise as physical, observable processes. The language used to describe these processes is alien to us (both linguistically and conceptually) but the processes themselves are familiar, offering us the opportunity to gain a clearer understanding of these texts than of other, more spiritual works.

The aim of studying Egyptian cosmography is to further our knowledge of the human perception and classification of the sky. The relationship between ourselves and celestial bodies has produced both philosophical and scientific thought, and led the Egyptians to apply their understanding of the sky to both spiritual and practical purposes. This study concentrates on the practical aspects of cosmography, and uses timekeeping methods to lead into the study of the depiction of the heavens.

The link between timekeeping and cosmography is evinced by the sources to be discussed in this study. The group of timekeeping stars known as decans evolved from a presumably practical origin into a symbolic group present in astronomical diagrams until the Greco-Roman period, illustrating their prominence as a recognised part of the sky. These diagrams are major sources for the study of cosmography, and also contain other timekeeping methods, for example the XXth dynasty diagrams include tables of the Ramesside star clock, a XVIIIth dynasty water-clock is decorated with an astronomical diagram, and the most interesting of all astronomical texts, the *Book of Nut*, contains within it both stellar and solar timekeeping methods.

The time period chosen, the New Kingdom, is selected as the area of Egyptian history during which the majority of timekeeping instruments were known and in use, whether practically or decoratively. Diagonal star clocks were already ancient, but the earliest surviving examples of other types of stellar timekeeping methods, shadow clocks, and water-clocks date from the New Kingdom. Foreign influences had not begun to enter the area of astronomy, but it was a time of increased interest in categorising and describing the world, and the time of the great astronomical ceilings which we shall also study. It has not been possible nor desirable to restrict research to methods and texts which definitely originated within the New Kingdom, as the exact dates of origin of most of the timekeeping methods and texts are not certain.

This study does not include the related fields of chronology and stellar alignment, nor does it aim to cover the wider issues of the basis of the Egyptian religion. These fields are somewhat distinct from the areas covered in this study, and have recent research devoted to them. It also does not attempt to identify specific Egyptian stars or constellations, which has been the ultimate goal of many researchers entering this field. In fact, this study shows clearly why such attempts must, with the present state of knowledge, either fail or be unprovable. The reason is that to make identifications, one must first make certain assumptions about Egyptian stellar timekeeping methods, and this study shows that even some of the more widely accepted assumptions are not as probable as was previously thought. It must be accepted that until we are reasonably sure that we understand how the timekeeping methods were constructed and used, we cannot begin to explore the area of stellar identification with any hope of success.

Also absent from this work is research into recent theories concerning the relationship between configurations of stars and configurations of constructions, and other 'astronomical' hypotheses which have been put forward in the present wave of pseudo-scientific 'non-fiction'. These publications have highlighted the vulnerability of scientific Egyptology to attack from outrageous theories, and have identified the need for Egyptian astronomy to be re-established as a serious, well-understood, and well integrated discipline.

This is not the only reason why the study of Egyptian astronomy is important. The subject stands at the intersection of many disciplines including history of astronomy, history of science and scientific thought, history of scientific instruments, philosophy, anthropology, theology, Egyptology, and the study of the Egyptian language. Each of these areas needs to integrate what knowledge we have of Egyptian astronomy into its own field, and each one is enriched by the incorporation of this early, written knowledge.

We must also acknowledge that although the amount of material which has survived from ancient times to the present is enormous, it is incomplete. Every area in Egyptology waits with anticipation for further sources to be discovered, and in the meantime theorises about the missing parts of our knowledge. Each study should therefore represent the best that we can achieve with our present level of knowledge and availability of sources, using the most up-to-date methods of analysis, but should acknowledge that we are part of a continuing search for increased understanding and that further discoveries could overthrow our carefully constructed work. No study can ever be said to be complete and definitive.

Previous work in this field has been undertaken by some of the greatest names in Egyptology: Champollion, Petrie, Brugsch, and Borchardt have all made major contributions to the study of Egyptian astronomy. More recently, in 1969, Otto Neugebauer and Richard Parker completed their great study *Egyptian Astronomical Texts* in three volumes which has become the standard reference work for the study of star clocks and celestial diagrams. Their work summarises all previous studies and publishes and analyses most sources pertinent to astronomy throughout the course of Egyptian history. In Volume 1 they present analyses of diagonal star clocks and the *Book of Nut*. Volume 2 is entirely concerned with the Ramesside star clock, while Volume 3 consists of an exhaustive catalogue and analysis of astronomical texts from monuments dating from the New Kingdom onwards. Their work is still the best representation of the existing state of knowledge in this field and will be referred to frequently in the present study.

More recently still, Marshall Clagett published the second volume of his series *Ancient Egyptian Science* which is entitled *Calendars, Clocks, and Astronomy*. He summarises previous work, covering a wider subject area than Neugebauer and Parker, but presents little new information and analysis.

Apart from these major works, there have also been publications dealing with narrower subject areas, many of which will be referred to in the present study. However, the quantity of publications on the subject of Egyptian astronomy is far lower than that, for example, in Egyptian mathematics, and to a large extent the publications have been tentative and isolated. There have, for example, been papers published recently which claim to have made the identification between certain stars and certain Egyptian names of constellations.[1] These identifications seem to be basically conjectural and it is often difficult to see what has been added to the sum of our knowledge by the publication of such theories.

In contrast, Christian Leitz's recent work on Ramesside star clocks[2] is a methodical attempt at analysing a timekeeping device, and ultimately produces some possibilities for identifications of Egyptian stars. Such a study is useful because Leitz's clearly presented

[1] Locher 'New identifications of Egyptian constellations', 'Probable Identification of the Ancient Egyptian Circumpolar Constellations', and 'A Conjecture Concerning the Early Egyptian Constellation of the Sheep'.
[2] Leitz *Altaegyptische Sternuhren.*

reasoning, his worries concerning the validity of his results, and the problems he encountered with his method, all add to our understanding of the device. Also, we know that one line of enquiry has been thoroughly investigated.

The present study aims to approach the subject methodically, dealing with each timekeeping method in turn before moving on to the area of cosmography. We start with analysis of pre-New Kingdom diagonal star clocks. After briefly reviewing the sources available to us, we discuss whether a classification system is a useful aid to the analysis of the sources. We look at decan lists in some detail, and will try to find out if, how, and when the diagonal star clock was updated. We shall also collect information about the possible motivation and construction of the diagonal star clock in preparation for our later attempt at tracing the development of such timekeeping methods.

In the next section, we move to the New Kingdom and look at instances of decan lists within timekeeping contexts. We shall see how the diagonal star clock survived into the New Kingdom, and introduce an important text, the *Book of Nut*. Whilst looking at one section of the *Book* we will begin to analyse the unique date list it contains.

Section C deals with a type of star clock which occurs only in the tombs of pharaohs from the XXth dynasty: the 'Ramesside star clock'. The section will question some of the assumptions which have gained wide acceptance, and will detail the problems of analysing these observationally-based timekeeping tables. A new theory will be presented together with supporting evidence which, it will be explained, solves some of the problems associated with the currently accepted method of usage of the tables.

The next section will take our findings from the three preceding star clock sections and attempt to outline the motivation for, development of, and links between the stellar timekeeping methods. The previous chapters will have highlighted some weaknesses in current theories concerning 'transit decans' and these will be extensively discussed.

The final timekeeping section will look at sundials, in particular the earliest type of formal sundial which has survived from ancient Egypt, the shadow clock. Since 1910, it has been generally accepted that the shadow clock should have an additional member, the crossbar. A small minority have expressed doubts about the validity of the addition. This section will present evidence against the crossbar hypothesis that will hopefully be considered to be conclusive.

The second part of this study will be based on New Kingdom representations of the sky. Two major texts and several celestial diagrams will be discussed in some detail, beginning in section F with the *Book of Nut*. We will use the text to investigate how the Egyptians perceived and described the motions of the sun and stars. We will discuss how the vignette which heads the *Book* can be read and interpreted, and new translations of the vignette texts and the dramatic text will be presented.

The other major text which will be discussed is the *Book of the Day*. This New Kingdom text describes the motion of the sun through the course of the day, providing an insight into the classification of the daylight hours, the behaviour of the sun, and the composition of its entourage. A particular portion of the text of the *Book of the Day* dealing with the circumpolar group of stars will be translated and discussed.

Finally, celestial diagrams dating from the New Kingdom will be described and analysed leading to the introduction of a model of the sky based on our findings in this part of the study. We will try to recreate the conceptual framework which the Egyptians used to understand the motions of the celestial bodies and use it to gain a small glimpse of the Egyptian sky.

Throughout the study, frequent reference will be made to the original sources of astronomical information. It is to these sources that we will turn to try to assess the validity of assumptions which have been used in previous studies and which have become entrenched in the popular consciousness; such assumptions as a strict definition of the time period or 'hour' that each timekeeping method was meant to measure and the existence of conceptual astronomical objects such as the meridian. These assumptions have even led to researchers imposing *a priori* conditions on the timekeeping methods, to the 'accuracy' of the methods being questioned, and to the whole field being termed primitive and uninteresting. Otto Neugebauer, even after his work on the three volumes of *Egyptian Astronomical Texts*, felt that 'Egypt has no place in a work on the history of mathematical astronomy ... its insignificance ... cannot be too strongly emphasised ... Egypt provides us with the exceptional case of a highly sophisticated civilisation which flourished for many centuries without making a single contribution to the development of the exact sciences.'[3]

All these difficulties stem from the problem of enabling the modern mind to approach the ancient instruments completely unbiased by our scientific concepts, methodology, and our own kinds of 'myth'. This is particularly true in the area of timekeeping. The modern and only recently established obsession with accurate timekeeping, both at a personal and national level, makes it difficult for us to tolerate ill-defined and variable time periods, and we find ourselves constantly hoping that an even 'hour' will leap out at us from our analysis of the ancient methods. In fact, as this study shows, we cannot gain any information about time periods without finding out more about the Egyptian timekeeping devices and methods. Any consideration of 'accuracy' is at the end of a very long list of questions to which we must first find answers. We will only achieve this by diligent analysis of what survives, by sympathetic reconstruction, and by constantly testing our assumptions.

[3] Neugebauer *History of Ancient Mathematical Astronomy* pp. 562-568.

This study attempts to learn as much as possible from contemporary documentation, practices, and motivations, before moving on to considerations of measured time periods. This process is aided by recent advances in our ability to translate texts. The new translations presented within this study owe much to the personal guidance of Dr Mark Collier, and follow his findings on the verb and auxiliary particles.[4]

Since Neugebauer and Parker's work, study of ancient astronomy has been greatly aided by increased access to computers, and by the development of software which can plot the stars at any date quickly and accurately. Spreadsheets are also particularly useful for completing repetitive calculation tasks and to provide instantly updated graphical output. These functions were particularly useful when analysing Ramesside star clocks and shadow clocks. However, the drawback of using computers for such tasks is their demand for accuracy, which colours our own perception of the results of such studies. In this study, such results have been used to indicate trends, to test the likelihood of certain hypotheses, and to illustrate different scenarios.

It is hoped that this study will show that some progress can be made towards a greater understanding of Egyptian astronomy from timekeeping methods and celestial diagrams by introducing new analysis methods and new theories, and by re-opening serious and scientific discussion about formerly accepted beliefs.

[4] Certain parts of Collier's work have recently been published in an accessible format in Collier and Manley *How to read Egyptian hieroglyphs*.

Conventions

Dates used in this study are those given by Baines and Malek in their *Atlas of Ancient Egypt*. A chronology of Egyptian dynasties with special emphasis on the New Kingdom is presented in the appendix. Where individual hieroglyphic signs are described, they are identified using Gardiner's system of classification from his *Egyptian Grammar.*

Where citations are given in footnotes, the author's surname and the title of the work (sometimes abbreviated for clarity) are given. The full citation may be found in the bibliography. Neugebauer and Parker's *Egyptian Astronomical Texts*, as the major reference for this study, is cited by title and volume alone.

PART I: TIMEKEEPING

Section A: Rising Star Clocks

Introduction

The earliest form of timekeeping device of which examples have survived to the present is the *rising star clock.* A star clock consisted of a table containing the names of asterisms and individual stars. These timekeeping stars are known as *decans*.

Each clock consists, in essence, of a table with twelve rows representing the hours of the night, and thirty-six columns representing the thirty-six decades (10-day periods) which make up the twelve months of the civil year. Table 1 shows the layout of a hypothetical ideal rising star clock. The numbers 1 to 36 and the letters A to L (omitting I) which appear in the main body of the table each represent a decan name. The main body of the table caters for 360 days, and is headed by a *date row* listing thirty-six decades. The diagonal pattern created by the decan names in this part of the table has led to the name *'diagonal star clock'*. The decan names represented by the letters A to L are usually called the *triangle decans*, again because of the shape they make in the star clock table. The decans 1 to 36 will be called *ordinary decans*.

The four leftmost columns of the table contain a list of all decans, the ordinary decans in the first three columns, the *list columns* (which do not appear to have any timekeeping purpose, but may have served as a reference list of decans used in the clock), and the eleven triangle decans A to L plus one extra triangle decan M in the final column. This *epagomenal column* served for timekeeping during the extra five whole days of the year (the epagomenal days, or 'days upon the year').

The table is divided into quarters by a *horizontal strip*, containing offering texts, and a *vertical strip* containing figures of deities associated with the sky.

[Epagomenal days]	Final decade	Middle decade	IV Shemu 1st decade	Final decade	Middle decade	III Shemu 1st decade	Final decade	Middle decade	II Shemu 1st decade	Final decade	Middle decade	I Shemu 1st decade	Final decade	Middle decade	IV Peret 1st decade	Final decade	Middle decade	III Peret 1st decade	Final decade	Middle decade	II Peret 1st decade	Final decade	Middle decade	I Peret 1st decade	Final decade	Middle decade	IV Akhet 1st decade	Final decade	Middle decade	III Akhet 1st decade	Final decade	Middle decade	II Akhet 1st decade	Final decade	Middle decade	I Akhet 1st decade
A 25 13 1	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
B 26 14 2	A	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2
C 27 15 3	B	A	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3
D 28 16 4	C	B	A	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4
E 29 17 5	D	C	B	A	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5
F 30 18 6	E	D	C	B	A	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6
G 31 19 7	F	E	D	C	B	A	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7
H 32 20 8	G	F	E	D	C	B	A	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8
J 33 21 9	H	G	F	E	D	C	B	A	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9
K 34 22 10	J	H	G	F	E	D	C	B	A	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10
L 35 23 11	K	J	H	G	F	E	D	C	B	A	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11
M 36 24 12	L	K	J	H	G	F	E	D	C	B	A	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12

Table 1: Idealised layout of a diagonal star clock

The table would have been used in the following manner:

An observer looks at the eastern horizon at any moment during the hours of darkness. He looks for a decan which is just visible above the horizon. Knowing the date, he looks at the rising star clock table and finds the column of twelve decan names which is headed by either the exact date, or by a date which occurred within the past nine days. He finds in that column the name of the decan that he has observed. The position of that decan in the column of twelve stars tells him the hour of the night. The first position indicating the first hour of the night and so on until the twelfth position indicating the twelfth hour of the night. For example, if decan 20 is rising above the eastern horizon and the day is in the middle decade of the first month of Peret, decan 20 is seventh in that column, therefore it is the seventh hour of the night.

Sources

Existing or recorded star clock tables in the form of Table 1 are painted on the inside surface of wooden coffin lids which date from the First Intermediate Period and the XIIth dynasty. The sources are listed below and numbered using the same order as Neugebauer and Parker,[5]

[5] *Egyptian Astronomical Texts* 1 pp. 2-3. Full details of sources A1 to A12 will be found in *Egyptian Astronomical Texts* 1, together with references for each.

who used date order and similarity with dated clocks to establish a numbering system for the first twelve sources. Four additional sources have since been recognised which are designated here as A13 to A17[6]. Each source is shown schematically in the manner of Neugebauer and Parker in the accompanying figures. (Grey dates indicate that a date line is not present in the original source, decan names refer to the decans in the first column and bottom row, while grey areas indicate damage on the original source.)

A1 *Msḥt* (S1C[7]) IX-Xth dynasty, from Asyut (Table 2)
A2 *ỉt-ỉb* (S3C) IX-Xth dynasty, from Asyut (Table 3)
A3 *Ḫw-n-Skr* usurped by *Ḫty* (S6C) IX-Xth dynasty, from Asyut (Table 4)
A4 *ỉdy* (S1Tü) date unknown, from Asyut (Table 5)
A5 *Mꜣꜥt* (S2Chass) IXth-Xth dynasty, from Asyut (Table 6)
A6 *ꜥꜣšyt* (T3C) XIth dynasty, from Thebes (Table 7)
A7 *ỉḳr* (G2T) First Intermediate Period or XIth dynasty, from Gebelein (Table 8)
A8 *Ḥḳꜣt* (A1C) date unknown, from Aswan (Table 9)
A9 *Ḫw-n-Skr* usurped by *Nḫt* usurped by *Ḥnn* (S3P) IX-Xth dynasty, from Asyut (Table 10)
A10 *Ṯꜣwꜣw* (S9C) XIIth dynasty, from Asyut (Table 11)
A11 *Ṯꜣwꜣw* (S5C) date unknown, from Asyut (Table 12)
A12 *Šms* (S11C) XIIth dynasty, from Asyut (Table 13)
A13 Name and date unknown (S#T) from Asyut[8] (Table 14)
A14 Name and date unknown (X2Bas) probably from Asyut[9] (Table 15)
A15 Name and date unknown (S16C) probably from Asyut[10] (Table 16)
A16 *Nḫt* (S1Hil) XI-XIIth dynasty, from Asyut[11] (Table 17, presented here for the first time in the format used by Neugebauer and Parker, and Figure 1)
A17 Name and date unknown (S2Hil) probably from Asyut[12] (Table 18)

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[6] Certain other coffin lids contain traces of diagonal star clocks: T3L (BM29570 belonging to *Sbk-ḥtp*, mentioned by Locher in 'Two further coffin lids' has an empty decan matrix); T2L (BM6655 belonging to *Mnṯw-ḥtp*); and S1X, which Willems (*Chests of life* list of coffins) identifies as the coffin of *Ḥny*, which is source 1 in *Egyptian Astronomical Texts* 1 (which is probably not a star clock, but will be dealt with in Section H), but which Lesko (*Index of the spells*) states is an entirely different coffin belonging to *Ḏfꜣ.ỉ-ḥꜥpy* whose texts have no references to decans.
[7] For coffin designations see Lesko *Index of the spells*.
[8] Although excavated in 1908, this source was unknown to Neugebauer and Parker. Details are given in: Locher 'A Further Coffin Lid'.
[9] First published in Lapp 'Särge des Mittelnreiches' then by Locher 'Two further coffin lids'.
[10] See Locher 'Middle Kingdom astronomical coffin lids'.
[11] Inv. Nr. 5999 in the Pelizaeus-Museum in Hildesheim. See Eggebrecht *Suche nach Unsterblichkeit* pp. 58-61 (including plates) and *Antike Welt* pl. 33 pp. 41-43.
[12] See Locher 'Middle Kingdom astronomical coffin lids'.

				IIII Shemu			III Shemu			II Shemu			I Shemu			IIII Peret			III Peret			II Peret			I Peret			IIII Akhet			III Akhet			II Akhet			I Akhet			
				3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	
	27	14	1	Date line																		Date line																		
A		15	2	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	*ṯm3t ḥrt*
B	28	16	3	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	*ṯm3t ḥrt*
C	29	17	4	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	*wšt bk3t*
D	30	18	5	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	*ipḏs*
E	31	19	6	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	*sbšsn*
F	32	20	7	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	*ḫntt ḥrt*
G	33	19	8	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	*ḫntt ḥrt*
K	34	22	9	G	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	*tms n ḫntt*
J	35	23	10	H	G	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	*kdty*
M	36	24	11	J	H	G	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	*[ḫnwy]*
to	1	25	12	K	J	H	G	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	*ḥry-ib wi3*
tal	4	26	13	M	K	J	H	G	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	[crew]
				pḥwy s3bw	*nṯr d3 pt*	*ḫ3w*	*3ḫwy*	*imy-ḫt spd*	*tpy-ʿ spd*	*ḫ3w*	*rmn ḥry*	*nṯr d3 pt*	*smd mḥty*	*smd rsy*	*ṯm3t ḥrt*	*ṯm3t ḥrt*	*pḥwy ḫ3w*	*ḥ3t ḫ3w*	*ḥry ḫpd n knmt*	*s3wy knmt*	*knmt*	*spd*	*tpy-ʿ spd*	*ḥrt wʿrt*	*ʿbwt*	*rmn ḥry*	*ḥry ʿrt*	*ʿrt*	*ḫ3w*	*kd*	*3ḫwy*	*imy-ḫt 3ḫwy*	*tpy-ʿ 3ḫwy*	*ḥry ḫpd srt*	*s3wy srt*	*srt*	*smd srt*	*k(n)m*	[crew]	

Table 2: Layout of A1

III Shemu			II Shemu			I Shemu			IIII Peret			III Peret			II Peret			I Peret			IIII Akhet			III Akhet			II Akhet			I Akhet			
3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	
	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	*ṯm3t ḥrt*
	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	*ṯm3t ḥrt*
	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	*wšt bk3t*
	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	*ipḏs*
	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	*sbšsn*
	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	*ḫntt ḥrt*
	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	*ḫntt ḥrt*
	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	*tms n ḫntt*
	26	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	*kdty*
	E	26	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	*[ḫnwy]*
	F	E	26	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	*ḥry-ib wi3*
	G	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	[crew]
	imy-ḫt spd	*tpy-ʿ spd*	*ḫ3w*	*rmn ḥry*	*nṯr d3 pt*	*smd mḥty*	*smd rsy*	*ṯm3t ḥrt*	*ṯm3t ḥrt*	*pḥwy ḫ3w*	*ḥ3t ḫ3w*	*ḥry ḫpd n knmt*	*s3wy knmt*	*knmt*	*spd*	*tpy-ʿ spd*	*ḥrt wʿrt*	*ʿbwt*	*rmn ḥry*	*ḥry ʿrt*	*ʿrt*	*ḫ3w*	*kd*	*3ḫwy*	*imy-ḫt 3ḫwy*	*tpy-ʿ 3ḫwy*	*ḥry ḫpd srt*	*s3wy srt*	*srt*	*smd srt*	*k(n)m*	[crew]	

Table 3: Layout of A2

III Peret		II Peret			I Peret				IIII Akhet			III Akhet			II Akhet			I Akhet			
2	1	3	2	1	3	2	1		3	2	1	3	2	1	3	2	1	3	2	1	
22	20	19	17	16	15	14	13		12	11	10	9	8	7	6	5	4	3	2	1	*tm3t ḥrt*
23	22	20	19	17	16	15	14		13	12	11	10	9	8	7	6	5	4	3	2	*tm3t ḫrt*
24	23	22	20	19	17	16	15		14	13	12	11	10	9	8	7	6	5	4	3	*wšt bk3t*
24	24	23	22	20	19	17	16		15	14	13	12	11	10	9	8	7	6	5	4	*ipḏs*
25	24	24	23	19	20	18	17		16	15	14	13	12	11	10	9	8	7	6	5	*sbššn*
26	25	24	24	22	19	20	18		17	16	15	14	13	12	11	10	9	8	7	6	*ḫntt ḥrt*
28	26	25	24	23	22	19	20		18	17	16	15	14	13	12	11	10	9	8	7	*ḫntt ḫrt*
29	28	26	25	24	23	22	19		20	18	17	16	15	14	13	12	11	10	9	8	*tms n ḫntt*
30	29	28	26	25	24	23	22		19	20	18	17	16	15	14	13	12	11	10	9	*ḳdty*
31	30	29	28	26	25	24	23		22	19	20	18	17	16	15	14	13	12	11	10	[*ḫnwy*]
32	31	30	29	28	26	25	24		23	22	19	20	18	17	16	15	14	13	12	11	*ḥry-ib wi3*
33	32	31	30	29	28	26	25		24	23	22	19	20	18	17	16	15	14	13	12	[crew]
s3wy knmt	*knmt*	*spd*	*tpy-ʿ spd*	*ḥrt wʿrt*	*ʿbwt*	*rmn ḥry*	*ḥry ʿrt*		*ʿrt*	*ḫ3w*	*ḳd*	*3ḫwy*	*imy-ḫt 3ḫwy*	*tpy-ʿ 3ḫwy*	*ḥry ḫpd srt*	*s3wy srt*	*srt*	*smd srt*	*k(n)m*	[crew]	

Table 4: Layout of A3

III Peret	II Peret			I Peret				IIII Akhet			III Akhet			II Akhet			I Akhet			
1	3	2	1	3	2	1		3	2	1	3	2	1	3	2	1	3	2	1	
18	16	17	14	13	12	11		12	11	10	9	8	7	6	5	4	3	2	1	*tm3t ḥrt*
20	18	16	17	14	13	12		13	12	11	10	9	8	7	6	5	4	3	2	*tm3t ḫrt*
19	20	18	16	17	14	13		14	13	12	11	10	9	8	7	6	5	4	3	*wšt bk3t*
22	19	20	18	16	17	14		15	14	13	12	11	10	9	8	7	6	5	4	*ipḏs*
23	22	19	20	18	16	17		17	15	14	13	12	11	10	9	8	7	6	5	*sbššn*
25	23	22	19	20	18	16		16	17	15	14	13	12	11	10	9	8	7	6	*ḫntt ḥrt*
26	25	23	22	19	20	18		18	16	16	15	14	13	12	11	10	9	8	7	*ḫntt ḫrt*
28	26	25	23	22	19	20		20	18	17	16	15	14	13	12	11	10	9	8	*tms n ḫntt*
29	28	26	25	23	22	19		19	20	18	17	16	15	14	13	12	11	10	9	*ḳdty*
30	29	28	26	25	23	22		22	19	20	18	17	16	15	14	13	12	11	10	[*ḫnwy*]
31	30	29	28	26	25	23		23	22	19	20	18	17	16	15	14	13	12	11	*ḥry-ib wi3*
32	31	30	29	28	26	25		24	23	22	19	20	18	17	16	15	14	13	12	[crew]
knmt	*spd*	*tpy-ʿ spd*	*ḥrt wʿrt*	*ʿbwt*	*rmn ḥry*	*ḥry ʿrt*		*ʿrt*	*ḫ3w*	*ḳd*	*3ḫwy*	*imy-ḫt 3ḫwy*	*tpy-ʿ 3ḫwy*	*ḥry ḫpd srt*	*s3wy srt*	*srt*	*smd srt*	*k(n)m*	[crew]	

Table 5: Layout of A4

II Peret	I Peret			IIII Akhet				III Akhet			II Akhet			I Akhet			
1	3	2	1	3	2	1		3	2	1	3	2	1	3	2	1	
16	15	14	13	12	11	10		8	8	8	6	5	4	3	2	1	*ṯm3t ḥrt*
17	16	15	14	13	12	11		10	7	7	7	6	5	4	3	2	*ṯm3t ẖrt*
18	17	16	15	14	13	12		11	10	9	8	7	6	5	4	3	*wšt bk3t*
20	18	17	16	15	14	13		12	11	10	9	8	7	6	5	4	*ipḏs*
19	20	18	17	16	15	14		13	12	11	10	9	8	7	6	5	*sbšsn*
22	19	20	18	17	16	15		14	13	12	11	10	9	8	7	6	*ẖntt ḥrt*
23	22	19	20	18	17	16		15	14	13	12	11	10	9	8	7	*ẖntt ẖrt*
24	23	22	19	20	18	17		16	15	14	13	12	11	10	9	8	*ṯms n ẖntt*
25	24	23	22	19	20	18		17	16	15	14	13	12	11	10	9	*ḳdty*
26	25	24	23	22	19	20		18	17	16	15	14	13	12	11	10	[*ẖnwy*]
28	26	25	24	23	22	19		20	18	17	16	15	14	13	12	11	*ḥry-ib wi3*
29	28	26	25	24	23	22		19	20	18	17	16	15	14	13	12	[crew]
ḥrt wꜥrt	*ꜥbwt*	*rmn ḥry*	*ḥry ꜥrt*	*ꜥrt*	*ḫ3w*	*ḳd*		*3ḫwy*		*tpy-ꜥ 3ḫwy*	*ḥry ḫpd srt*	*s3wy srt*	*srt*	*smd srt*	*k(n)m*	[crew]	

Table 6: Layout of A5

			IIII Shemu		III Shemu			II Shemu			I Shemu			IIII Peret			III Peret			II Peret		II Peret		I Peret			IIII Akhet			III Akhet			II Akhet			I Akhet			
			2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3		2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	
33	15	1	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20		17	15	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	*ṯm3t ḥrt*
34	16	2	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19		18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	*ṯm3t ẖrt*
35	17	3	B	A	2	1	36	35	34	33	32	31	30	30	28	23	25	24	23	22		20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	*wšt bk3t*
36	18	4	C	B	A	2	1	36	35	34	33	32	31	31	30	26	23	25	24	23		22	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	*ipḏs*
1	20 22	5	26	C	B	A	2	1	36	35	34	33	32	32	31	29	26	26	25	24		23	22	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	*sbšsn*
31	24	7	E	26	C	B	A	2	1	36	35	34	33	29	29	30	29	28	30	25		24	23	22	20	15	17	16	15	14	13	12	11	10	9	8	7	6	*ẖntt ḥrt*
BA	25	7	F	E	26	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26		25	24	19	22	20	18	17	16	15	14	13	12	11	10	9	8	7	*ẖntt ẖrt*
C	26	8	G	F	E	26	C	B	A	2	1	36	35	34	33	32	31	30	29	28		20	25	23	23	19	20	18	17	16	15	14	13	12	11	10	9	8	*ṯms n ẖntt*
D	28	9	H	G	F	D	26	C	B	A	2	1	36	35	34	33	32	31	30	29		26	20	24	24	22	19	20	18	17	16	15	14	13	12	11	10	9	*ḳdty*
E	29	10	J	H	G	E	E	26	C	B	A	2	1	36	35	34	33	32	31	30		28	26	25	25	23	22	19	20	18	17	16	15	14	13	12	11	10	[*ẖnwy*]
F KL	30	11 12	K	J	H	F	F	E	26	C	B	A	2	1	36	35	34	33	32	31		29	28	26	20	24	23	22	19	20	18	17	16	15	14	13	12	11	*ḥry-ib wi3*
M	32	14 13	M	K	J	G	G	F	E	D	C	B	A	2	1	36	35	34	33	32		18	29	28	26	20	24	23	22	19	20	18	17	16	15	14	13	12	[crew]
			pḥwy s3bw	*nṯr d3 pt*	*ḫ3w*	*imy-ḫt spd*	*imy-ḫt spd*	*tpy-ꜥ spd*	*ḫ3w*	*rmn ḥry*	*nṯr d3 pt*	*smd mḥty*	*smd rsy*	*ṯm3t ẖrt*	*ṯm3t ḥrt*	*pḥwy ḫ3w*	*ḫ3t ḫ3w*	*ḥry ḫpd n knmt*	*s3wy knmt*	*knmt*		*tpy-ꜥ 3ḫwy*	*ḥrt wꜥrt*	*ꜥbwt*	*rmn ḥry*	*imy-ḫt 3ḫwy*	*ꜥrt*	*ḫ3w*	*ḳd*	*3ḫwy*	*imy-ḫt 3ḫwy*	*tpy-ꜥ 3ḫwy*	*ḥry ḫpd srt*	*s3wy srt*	*srt*	*smd srt*	*k(n)m*	[crew]	

Table 7: Layout of A6

			IIII Shemu			III Shemu			II Shemu			I Shemu			IIII Peret			III Peret			II Peret			I Peret			IIII Akhet			III Akhet			II Akhet			I Akhet			
			3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	
33	15	1	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	*ṯm3t ḥrt*
34	16	3	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	*ṯm3t ḫrt*
35	18	4	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	22	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	*wšt bk3t*
36	20	5	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	23	22	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	*ipḏs*
1	19	6	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	24	23	22	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	*sbšsn*
A	22	7	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	25	24	23	22	20	18	17	16	15	14	13	12	11	10	9	8	7	6	*ḫntt ḥrt*
C	25	8	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	19	25	24	23	22	20	18	17	16	15	14	13	12	11	10	9	8	7	*ḫntt ḫrt*
D	26	9	G	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	19	25	24	23	22	20	18	17	16	15	14	13	12	11	10	9	8	*ṯms n ḫntt*
K	28	10	H	G	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	19	25	24	23	22	20	18	17	16	15	14	13	12	11	10	9	*ḳdty*
M	29	11	J	H	G	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	19	25	24	23	22	20	18	17	16	15	14	13	12	11	10	*[ḫnwy]*
	30	12	K	J	H	G	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	19	25	24	23	22	20	18	17	16	15	14	13	12	11	*ḥry-ib wi3*
x	32		M	K	J	H	G	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	19	25	24	23	22	20	18	17	16	15	14	13	12	[crew]
			pḥwy s3bw	*nṯr ḏ3 pt*	*ḫ3w*	*3ḫwy*	*imy-ḫt spd*	*tpy-ꜥ spd*	*ḫ3w*	*rmn ḥry*	*nṯr ḏ3 pt*	*smd mḥty*	*smd rsy*	*ṯm3t ḥrt*	*ṯm3t ḥrt*	*pḥwy ḫ3w*	*ḥ3t ḫ3w*	*ḥry ḫpd n knm*	*s3wy knmt*	*knmt*	*spd*	*tpy-ꜥ spd*	*ḥrt wꜥrt*	*ꜥbwt*	*rmn ḥry*	*3ḫwy*	*ḥry ꜥrt*	*ꜥrt*	*ḫ3w*	*ḳd*	*imy-ḫt 3ḫwy*	*tpy-ꜥ 3ḫwy*	*ḥry ḫpd srt*	*s3wy srt*	*srt*	*smd srt*	*k(n)m*	[crew]	

Table 8: Layout of A7

			IIII Shemu			III Shemu			II Shemu			I Shemu			IIII Peret			III Peret			II Peret			I Peret			IIII Akhet			III Akhet			II Akhet			I Akhet			
			3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	
29	28	25	33	15	1	2	1	36	35	34	33	32	31	30	26	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	*ṯm3t ḥrt*
34	16	3	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	*ṯm3t ḫrt*
35	18	4	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	22	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	*wšt bk3t*
36	20	5	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	23	22	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	*ipḏs*
1	19	6	26	C	2 1	B	A	2	1	35	34	33	32	31	30	29	28	26	25	24	24	23	22	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	*sbšsn*
A	22	7	E	D 26	2	1	B	A	2	1	35	34	33	32	31	30	29	28	26	25	25	24	23	22	20	18	17	16	15	14	13	12	11	10	9	8	7	6	*ḫntt ḥrt*
F	C	25	8	F	E	D	C	B	A	2	1	36	35	34	33	32	30	29	28	26	19	25	25	24	23	22	20	18	17	16	15	14	13 12	11	10	9	8	7	*ḫntt ḫrt*
A	D	26	9	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	19	25	24	23	22	20	18	17	16	15	14	13	12	11	10	9	8	*ṯms n ḫntt*
LK	28	10	H	G	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	19	25	24	23	22	20	18	17	16	15	14	13	12	11	10	9	*ḳdty*
M	29	11	J	H	G	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	19	25	24	23	22	20	18	17	16	15	14	13	12	11	10	*[ḫnwy]*
	30	12	K	J	H	G	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	19	25	24	23	22	20	18	17	16	15	14	13	12	11	*ḥry-ib wi3*
M	32	14 13	M	K	J	H	G	F	E	D	C	B	A	2	1	36	35	34	33	32	31	30	29	28	26	19	25	24	23	22	20	18	17	16	15	14	13	12	[crew]
			pḥwy s3bw	*nṯr ḏ3 pt*	*ḫ3w*	*3ḫwy*	*imy-ḫt spd*	*tpy-ꜥ spd*	*ḫ3w*	*rmn ḥry*	*nṯr ḏ3 pt*	*smd mḥty*	*smd rsy*	*ṯm3t ḥrt*	*ṯm3t ḥrt*	*pḥwy ḫ3w*	*ḥ3t ḫ3w*	*ḥry ḫpd n knmt*	*s3wy knmt*	*knmt*	*spd*	*tpy-ꜥ spd*	*ḥrt wꜥrt*	*ꜥbwt*	*rmn ḥry*	*3ḫwy*	*ḥry ꜥrt*	*ꜥrt*	*ḫ3w*	*ḳd*	*imy-ḫt 3ḫwy*	*tpy-ꜥ 3ḫwy*	*ḥry ḫpd srt*	*s3wy srt*	*srt*	*smd srt*	*k(n)m*	[crew]	

Table 9: Layout of A8

III Peret			II Peret			I Peret				IIII Akhet			III Akhet			II Akhet			I Akhet			
3	2	1	3	2	1	3	2	1		3	2	1	3	2	1	3	2	1	3	2	1	
19	20	17	18	16	15	14	13	12		11	10	9	8	7	6	5	4	3b	3a	2	1	*ṯmꜣt ḥrt*
22	19	20	17	18	16	15	14a	13		12	11	10	9	8	7	6	5	4	3b	3a	2	*ṯmꜣt ḫrt*
23	22	19	20	17	18	16	15	14a		13	12	11	10	9	8	7	6	5	4	3b	3a	*wšꜣti*
24	23	22	19	20	17	18	16	15		14a	13	12	11	10	9	8	7	6	5	4	3b	*bkꜣti*
25	24	23	22	19	20	17	18	16		15	14a	13	12	11	10	9	8	7	6	5	4	*ipḏs*
26	25	24	23	22	19	20	17	18		16	15	14a	13	12	11	10	9	8	7	6	5	*sbšsn*
28	26	25	24	23	22	19	20	17		17	16	15	14a	13	12	11	10	9	8	7	6	*ḫntt ḥrt*
29	28	26	25	24	23	22	19	20		18	17	16	15	14a	13	12	11	10	9	8	7	*ḫntt ḫrt*
30	29	28	26	25	24	23	22	19		20	18	17	16	15	14a	13	12	11	10	9	8	*ṯms n ḫntt*
31	30	29	28	26	25	24	23	22		19	20	18	17	16	15	14a	13	12	11	10	9	*ḳdty*
32	31	30	29	28	26	25	24	23		22	19	20	18	17	16	15	14a	13	12	11	10	*[ḫnwy]*
33	32	31	30	29	28	26	25	24		23	22	19	20	18	17	16	15	14a	13	12	11	*ḥry-ib wiꜣ*
sꜣwy knmt	*knmt*	*spd*	*tpy-ꜥ spd*	*ḫrt wꜥrt*	*ꜥbwt*	*rmn ḥry*	*ḥry ꜥrt*	*ꜥrt*		*ḫꜣw*	*ḳd*	*ꜣḫwy*	*imy-ḫt ꜣḫwy*	*tpy-ꜥ ꜣḫwy*	*ḥry ḫpd srt*	*sꜣwy srt*	*srt*	*smd*	*k(n)m*	[crew]	*ḥry-ib wiꜣ*	

Table 10: Layout of A9

IIII Peret		III Peret			II Peret			I Peret				IIII Akhet			III Akhet			II Akhet			I Akhet			
2	1	3	2	1	3	2	1	3		2	1	3	2	1	3	2	1	3	2	1	3	2	1	
	15	14a	10a	11	9a	3b	3a	7		6	5a	7	6	5a	3b	3b	36a	35a	34	31a	32	2		
17	16	15	14a	12a	10a	9a	3b	3a		7	6	5a	7	6	5a	3b	3b	36a	35a	34	31a	32	2	*ṯmꜣt ḥrt*
18	17	16	15	14a	12a	9a	10a	9a		3a	7	6	5a	7	6	5a	3b	3b3a	36a	35a	34	31a	32	*knmt*
	18		16	15		13	12a	10a		3b	3a	5a	7	3a	3b	3b	5a	3b	3b	36a		35a	31a	*tpy-ꜥ knmt*
	19	18	18	14a	18	34	12a	22a		8	9a	6	3a	3b	5a	9a	3a	3b	3a	3a	36a	35a		*ḥꜣt ḏꜣt*
	19	19	19	15	19	18	13	22		10a	9a	8	3b	5a	9a	10a	6	5a	3b	3b	1	36a		*pḥwy ḏꜣt*
21b	22	21	21	16	20	20	14a	14a		9a	10a	9a	5a	3a	10a	11	7	6	5a	3a	2	1		*ṯmꜣt ḥrt*
	22a	22	21a	17	19	19	22	22		11	11	10a	6	3b	11	3a	10a	7	6	3b	3a	2		*ṯmꜣt ḫrt*
ḫntw ḥrw	*sꜣwy ḳd*	*ḳd*	*ḫntw ḥrw*	*ḥry ḫpd srt*	*ꜣḫwy*	*ꜣḫwy*	*ḳd*	*ḳd*		*ḥry-ib wiꜣ*	*ḥry-ib wiꜣ*	*ḫnwy*	*ḫntt ḫrt*	*bkꜣti*	*ḥry-ib wiꜣ*	*wšꜣti*	*ḫnwy*	*ḫntt ḫrt*	*ḫntt ḥrt*	*bkꜣti*	*wšꜣti*	*ṯmꜣt ḥrt*		

Table 11: Layout of A10

IIII Peret			III Peret			II Peret			I Peret			IIII Akhet			III Akhet			II Akhet			I Akhet				
3	2	1	3	2		1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	
18	17	16	15	14a		12a	11		36a	36a	36a	4a	7	6	5a	1	3a	3a	2	1	4a	34	32	31a	*tpy-ʿ knmt*
17	16	15	14a	11		11	8	36a	35a	35a	35a	4a	7	6	31a	3a	32	34	34	4a	3b	32	31a	32	*knmt*
	15	14a	11	35a		8	9b	35a	4a	4a	4a	3a	32	32	3a	32	2	4a	4a	3b	3a	31a	35a	35a	*ḥ3t ḏ3t*
	14a	11	35a	36a		9b	11	4a	3a	32	3a	7	6	5a	32	2	1	3b	3b	3a	32	35a	36a	36a	*pḥwy ḏ3t*
14a	11	35a	36a	4a		11	12a	3a	7	32	7	6	5a	4a	2	1	3b	3a	3a	32	31a	1	1	1	*ṯm3t ḥrt*
11	35a	36a	4a	9b		12a		7	32	7	6	5a	4a	1	1	3b	32	32	32	31a	32	2	2	2	*ṯm3t ẖrt*
	11	14a	5	31		35a	3a	4a	1	1	13	13	13a	15	16	3a	31a	19	21	21a	21b	35a	36a	23	*ḫ3w*
11	14a	12a	31	27b		3a	4a	1	2	2	13a	13a	14a	16	3a	31a	19	21	21a	21b	35a	36a	23	22	*ḳd*
	12a	5	27b	31b		4a	1	2	32	32	14a	14a	15	3a	31a	19	21a	21a	21b	35a	36a	23	22	24	*ʿrt*
	5	31	31b	4		1	2	32	13	13a	15	15	16	31a	19	21a	21b	21b	35a	36a	23	22	24	26a	*rmn ḥry s3ḥ*
	31	27b	4	24		2	32	13	13a		32	32	32	19	21a	21b	32	32	36a	23	22	24	26a	27a	*rmn ẖry s3ḥ*
	27b	24	24	3a		32	13	13a	14a		16	16	31a	21a	21b	32	1	1	23	22	24	26a	27a	22	*ḳd*
	rmn s3ḥ	*ʿrt*	*ʿrt*	*wš3ti*		*knmt*	*k(n)m*	*tpy-ʿ smd*	*smd*		*s3wy srt*	*s3wy srt*	*tpy-ʿ knmt*	*ḫntw ḥrw*	*ḫntw ḥrw*	*knmt*	*ṯm3t ḥrt*	*ṯm3t ẖrt*	*ḫ3w*	*ḳd*	*ʿrt*	*rmn ḥry s3*	*rmn ẖry s3*	*ḳd*	

Table 12: Layout of A11

II Peret			I Peret				IIII Akhet			III Akhet			II Akhet			I Akhet		
2	1	3	2	1	3	2		1	3	2	1	3	2	1	3	2	1	
13	12a	11	9b	8	7	6		5a	3b	3a	2	1	36a	35a	34	32	31a	*tpy-ʿ knmt*
13a	13	12a	11	9b	8	7		6	5a	3b	3a	2	1	36a	35a	34	32	*knmt*
14a	13a	13	12a	11	9b	8		7	6	5a	3b	3a	2	1	36a	35a	34	*ẖry ḫpd n knmt*
15	14a	13a	13	12a	11	9b		8	7	6	5a	3b	3a	2	1	36a	35a	*ḥ3t ḏ3t*
16	15	14a	13a	13	12a	11		9b	8	7	6	5a	3b	3a	2	1	36a	*pḥwy ḏ3t*
17	16	15	14a	13a	13	12a		11	9b	8	7	6	5a	3b	3a	2	1	*ṯm3t ḥrt*
18	17	16	15	14a	13a	13		12a	11	9b	8	7	6	5a	3b	3a	2	*ṯm3t ẖrt*
21	18	17	16	15	14a	13a		13	12a	11	9b	8	7	6	5a	3b	3a	*wš3ti*
21a	21	18	17	16	15	14a		13a	13	12a	11	9b	8	7	6	5a	3b	*bk3ti*
21b	21a	21	18	17	16	15		14a	13a	13	12a	11	9b	8	7	6	5a	*tpy-ʿ ḫntt*
22	21b	21a	21	18	17	16		15	14a	13a	13	12a	11	9b	8	7	6	*ḫntt ḥrt*
22a	22	21b	21a	21	18	17		16	15	14a	13a	13	12a	11	9b	8	7	*ḫntt ẖrt*
s3wy ḳd	*ḳd*	*ḫntw ḥrw*	*ḫntw ḥrw*	*b3wy*	*tpy-ʿ 3ḫwy*	*ḥry ḫpd srt*		*s3wy srt*	*srt*	*smd*	*tpy-ʿ smd*	*k(n)m*	*sšmw*	*ḥry-ib wi3*	*spty ḫnwy*	*tms n ḫntt*	*ḫntt ḥrt*	

Table 13: Layout of A12

III Peret		II Peret			I Peret			IIII Akhet				III Akhet			II Akhet			I Akhet		
1	3	2	1	3	2	1	3		2	1	3	2	1	3	2	1	3	2	1	
13a	13	12a	11	9b	8	7	6		5a	4a	3b	3a	2	1	36a	35a	34			
14a	13a	13	12a	11	9b	8	7		6	5a	4a	3b	3a	2	1	36a	35a	34		
15	14a	13a	13	12a	11	9b	8		7	6	5a	4a	3b	3a	2	1	36a	35a	34	*ẖry ḫpd n knmt*
16	15	14a	13a	13	12a	11	9b		8	7	6	5a	4a	3b	3a	2	1	36a	35a	*ḥ3t ḏ3t*
17	16	15	14a	13a	13	12a	11		9b	8	7	6	5a	4a	3b	3a	2	1	36a	*pḥwy ḏ3t*
18	17	16	15	14a	13a	13	12a		11	9b	8	7	6	5a	4a	3b	3a	2	1	*ṯm3t ḥrt*
19	18	17	16	15	14a	13a	13		12a	11	9b	8	7	6	5a	4a	3b	3a	2	*ṯm3t ẖrt*
21x	19	18	17	16	15	14a	13a		13	12a	11	9b	8	7	6	5a	4a	3b	3a	*wš3ti*
21a	21a	21	18	17	16	15	14a		13a	13	12a	11	9b	8	7	6	5a	4a	3b	*bk3ti*
22	21x	21x	19	18	17	16	15		14a	13a	13	12a	11	9b	8	7	6	5a	4a	*sšpt*
22a	22	21x	21x	19	18	17	16		15	14a	13a	13	12a	11	9b	8	7	6	5a	*tpy-ʿ ḫntt*
23	22a	22	21x	21x	19	18	17		16	15	14a	13a	13	12a	11	9b	8	7	6	*ḫntt ḥrt*
ḫ3w	*s3wy ḳd*	*ḳd*	*ḫntw ḥrw qr ḥı*	*ḫntw ḥrw qr ḥı*	*3ḫwy*	*tpy-ʿ 3ḫwy*	*ḥry ḫpd srt*		*s3wy srt*	*srt*	*smd*	*tpy-ʿ smd*	*k(n)m*	*sšmw*	*ḥry-ib wi3*	*spty ḫnwy*	*tms n ḫntt*	*ḫntt ḥrt*	*ḫntt ḥrt*	

Table 14: Layout of A13

IIII Akhet			III Akhet			III Akhet	II Akhet			I Akhet			
3	2	1	3	2		1	3	2	1	3	2	1	
7	6	5a	4a	3b		3a	2	1	36a	35a	34	32	*knmt*
8	7	6	5a	4a		3b	3a	2	1	36a	35a	34	*ḥry ẖpd n knmt*
9b	8	7	6	5a		4a	3b	3a	2	1	36a	35a	*ḥ3t ḏ3t*
11	9b	8	7	6		5a	4a	3b	3a	2	1	36a	*pḥwy ḏ3t*
12a	11	9b	8	7		6	5a	4a	3b	3a	2	1	*ṯm3t ḥrt*
13	12a	11	9b	8		7	6	5a	4a	3b	3a	2	*ṯm3t ẖrt*
14a	13	12a	11	9b		8	7	6	5a	4a	3b	3a	*wš3ti*
15	14a	13	12a	11		9b	8	7	6	5a	4a	3b	*bk3ti*
srt	*smd*	*k(n)m*	*sšmw*	*ḥry-ib wi3*		*spty ẖnwy*	*ṯms n ẖntt*	*ẖntt ḥrt*	*ẖntt ẖrt*	*tpy-ʿ ẖntt*	*sšpt*	*bk3ti*	

Table 15: Layout of A14

III Peret			II Peret			I Peret			IIII Akhet			III Akhet			II Akhet			I Akhet		
2	1		3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1
																		3	2	
																		4	3	
																		5	4	
																		6		
																	8	7		
25																10	9			
								20												
								19		18										
									19											
											20	18								
																		14		
																		smd srt		

Table 16: Layout of A15

I Shemu 3	I Shemu 2	I Shemu 1	IIII Peret 3	IIII Peret 2	IIII Peret 1	III Peret 3	III Peret 2	III Peret 1	II Peret 3	II Peret 2	II Peret 1	I Peret 3	I Peret 2	I Peret 1	IIII Akhet 3	IIII Akhet 2	IIII Akhet 1	III Akhet 3	III Akhet 2	III Akhet 1	II Akhet 3	II Akhet 2	II Akhet 1	I Akhet 3	I Akhet 2	I Akhet 1	
29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	*ṯmꜣt ḥrt*
30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	*ṯmꜣt ḫrt*
31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	*wšt bkꜣt*
32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	*ipḏs*
33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	5	*sbšsn*
34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	6	*ḫntt ḥrt*
35	34	33	32	31	30	29	28	26	24	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	7	*ḫntt ḫrt*
36	36	34	33	32	31	30	29	28	25	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	8	*ṯms n ḫntt*
1	1	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	9	*ḳdty*
1	2	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	10	[*ḫnwy*]
A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	11	*ḥry-ib wiꜣ*
B	A	2	1	36	35	34	33	32	31	30	29	28	26	25	24	23	22	19	20	18	17	16	15	14	13	12	[crew]
smd mḥty	*smd rsy*	*ṯmꜣt ḫrt*	*ṯmꜣt ḥrt*	*pḥwy ḫꜣw*	*ḥꜣt ḫꜣw*	*ḥry ḫpd n knmt*	*sꜣwy knmt*	*knmt*	*spd*	*tpy-ꜥ spd*	*ḫrt wꜥrt*	*ꜥbwt*	*rmn ḥry*	*ḥry ꜥrt*	*ꜥrt*	*ḫꜣw*	*ḳd*	*ꜣḫwy*	*imy-ḫt ꜣḫwy*	*tpy-ꜥ ꜣḫwy*	*ḥry ḫpd srt*	*sꜣwy srt*	*srt*	*smd srt*	*k(n)m*	[crew]	

Table 17: Layout of A16

II Peret 3	II Peret 2	II Peret 1	I Peret 3	I Peret 2	I Peret 1	IIII Akhet 3	IIII Akhet 2	IIII Akhet 1	III Akhet 3	III Akhet 2	III Akhet 1	II Akhet 3	II Akhet 2	II Akhet 1	I Akhet 3	I Akhet 2	I Akhet 1	
										8								
															7	6		
24	23		18		16				13	12	10			10				
25	24	23	20	18	16				14	13	11		12	11				
	25	24	23	20					15	14	12			12	11			
		25	24						16		13							
			25			18				16						12	11	*ḥry-ib wiꜣ*
			ḥry ꜥrt			*tpy-ꜥ ꜣḫwy*				*sꜣwy srt*						[crew]	*ḥry-ib wiꜣ*	

Table 18: Layout of A17

Figure 1: Hildesheim Inv. Nr. 5999
(from Eggebrecht *Suche nach Unsterblichkeit*)

Grouping the Tables

The star clock tables A1 to A12 have been extensively analysed by Neugebauer and Parker who remark that most tables are in some way corrupted.[13] Copyists' mistakes are rife in the main part of the table and many of the sources are incomplete. Neugebauer and Parker grouped the tables by considering the decans used and the arrangement of elements in the vertical strip. They identified five groups, which they labelled Group I (consisting of sources A1, A2, A3, A4, and A5), Group II (A6, A7, and A8), Group III (A9), Group IV (A10), and Group V (A11 and A12). Leaving the consideration of decan lists until the next section, let us briefly examine the three layout elements of date row, vertical strip content, and horizontal strip content which contributed to this classification system.

A3, A6, A10, A11, A12, A13, A14, and A15 do not have a date row, leaving Groups I and II split if this factor is considered important in grouping the tables.

The vertical strip[14] contains four figures, often captioned. In A1 to A5, A9, A13, A14, and A16 the order of figures from top to bottom is: Nut, Foreleg, Orion, Sirius. In A6, A7, A8, A10, and A17 the order is reversed. In A11 and A12 the order is Sirius, Foreleg, Orion, Nut. This factor creates three groups of sources, one containing Neugebauer and Parker's Groups I and III and the additional sources A13, A14, and A16, the second consisting of Groups II and IV plus A17, and the third of the single Group V.

The horizontal strips[15] contain offering texts to various deities and decans for the deceased, starting in all cases with an offering to Re (although unreadable in A13, this can be safely assumed). The strip continues with offerings to Foreleg, Nut, Orion, Sirius, and then to

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[13] *Egyptian Astronomical Texts* 1 p. 23.
[14] *Egyptian Astronomical Texts* 1 pp. 28-29.
[15] *Egyptian Astronomical Texts* 1 pp. 26-28, Locher 'A further coffin lid' (A13) and 'Two further coffin lids' (A14), Eggebrecht *Suche nach Unsterblichkeit* p. 59 and *Antike Welt* pl. 33 (A16). Contents of the horizontal strips of A15 and A17 has not been published.

various decans.

Five sources, A1, A3, A4, A6, and A13, have offerings to Foreleg, Nut, and Orion before other offerings to decans. Sirius is omitted entirely. Four sources, A2, A5, A9, and A16, have Sirius following Foreleg, Nut, and Orion and preceding the decans. Of the remaining sources, A7 has Nut, Orion, and then probably Foreleg and Sirius, which is the definite order in A8. A10 has only Orion and Foreleg and no decans. A12 has Orion, Foreleg, and Sirius. A11 has only Foreleg readable as the first offering after Re. A14 has Orion, Foreleg and then Nut after one decan.

Clearly the space available has a great impact on the length of the decanal part of the offering formula painted on the coffin lids. The order and inclusion of the four deities Foreleg, Nut, Orion, and Sirius is not usually subject to the same constraint (except in the case of A10). Is the order an important factor in classifying the tables? Neugebauer and Parker's Groups I and II are again split when this factor is considered. Furthermore, so is Group V.

In summary, from the three factors considered above only the order of figures in the vertical strip agrees with Neugebauer and Parker's system by not splitting any of the groups. This factor, however, produces only three distinct groups instead of five. These three factors are primarily of artistic importance. In the analysis of the tables as timekeeping devices, they have no relevance. We still need to turn our attention to the major attribute of the tables: the decans; but we shall soon see that once again, the concept of five groups is not upheld by the decan lists, and we conclude that such a system of groups is not useful in the analysis of the star clock tables.

This conclusion is clearly illustrated by Locher's diagrammatic attempt at showing the characteristics of fifteen sources, here reproduced as Figure 2. Locher's diagram uses seven factors in addition to Neugebauer and Parker's series of groups to position the sources within the diagram. These include the order of deities in the vertical strip, the inclusion or omission of certain decans, the decan used in the upper right cell (first decan in the table), provenance, and two epigraphic points (pertinent to sources A11, A12, and A13). Locher omits two of the layout factors which we have already mentioned, inclusion of a date row and the sequence of offerings in the horizontal strip, which split Neugebauer and Parker's groups. The system was originally designed[16] to incorporate thirteen sources (A1 to A13), but after the publication of two further sources (A14 and an empty decan matrix), Locher found that his system could not incorporate the inclusion of these extra sources without distortion,[17] and abandoned it in subsequent publications.

Kahl[18] has recently attempted to classify certain of the sources into a stemma showing development from an original basis he denotes as α. Locher has combined this approach with Neugebauer and Parker's five groups to produce a system of classification of A1 to A17 plus the empty matrix source mentioned above (Figure 3).

Even before considering the area of prime interest in these sources, the decan lists, we are able to see that no classification system has been capable of incorporating newly identified sources without modification, and none has been universally accepted. This is an indication that the number of examples of star clock tables which have survived is not sufficient for a meaningful classification system to be devised which incorporates all points of layout, epigraphy, origin, and age. The systems developed so far have added very little to our understanding of the tables and seem to have diverted attention from the potentially more rewarding study of development of astronomy and timekeeping in ancient Egypt.

16 Figure 1 in Locher 'A Further Coffin Lid'.
17 Locher 'Two further coffin lids'.
18 Kahl 'Textkritische Bemerkungen'.

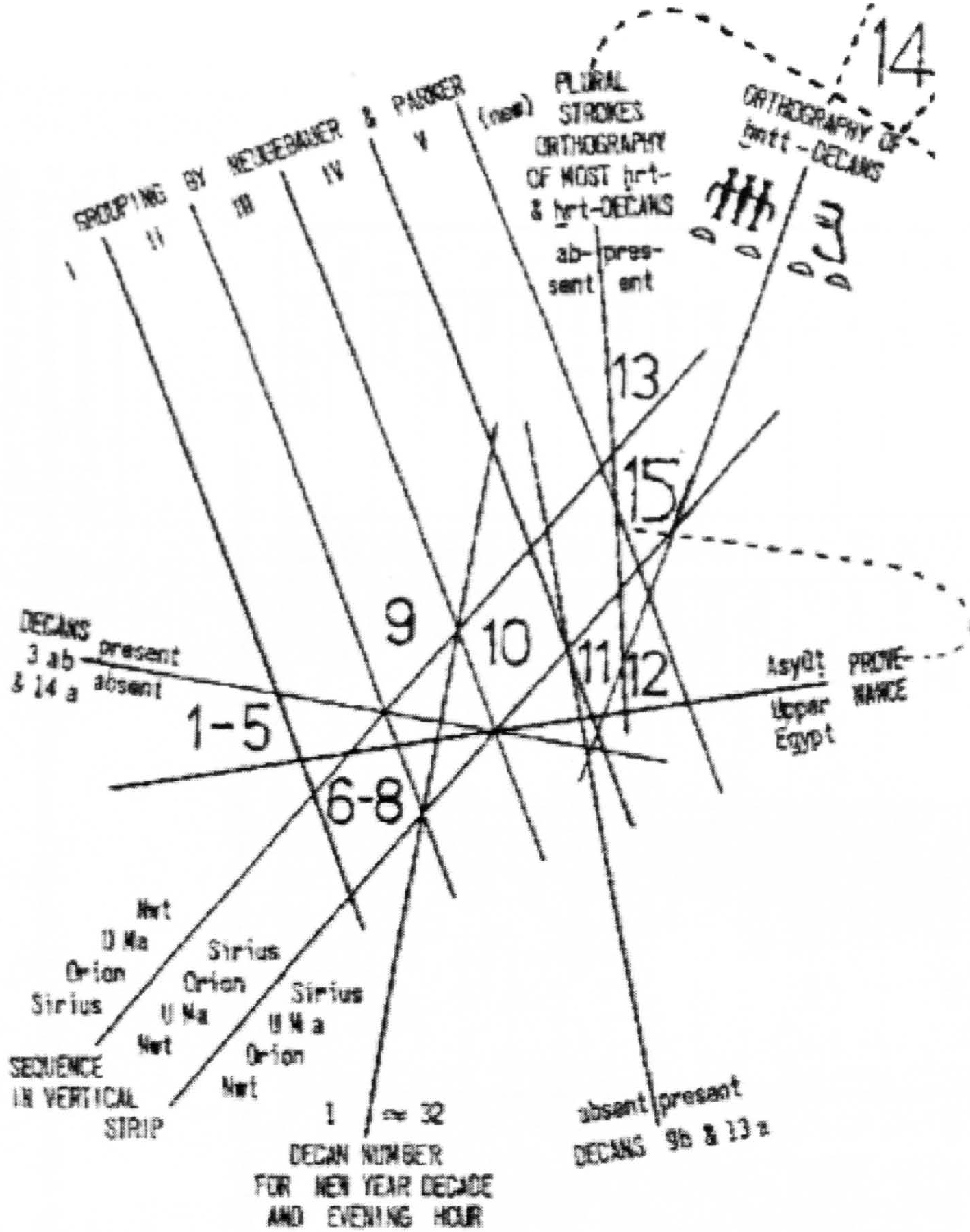


Figure 2: Locher's diagram of diagonal star clock classification
(from Locher 'Two further coffin lids')

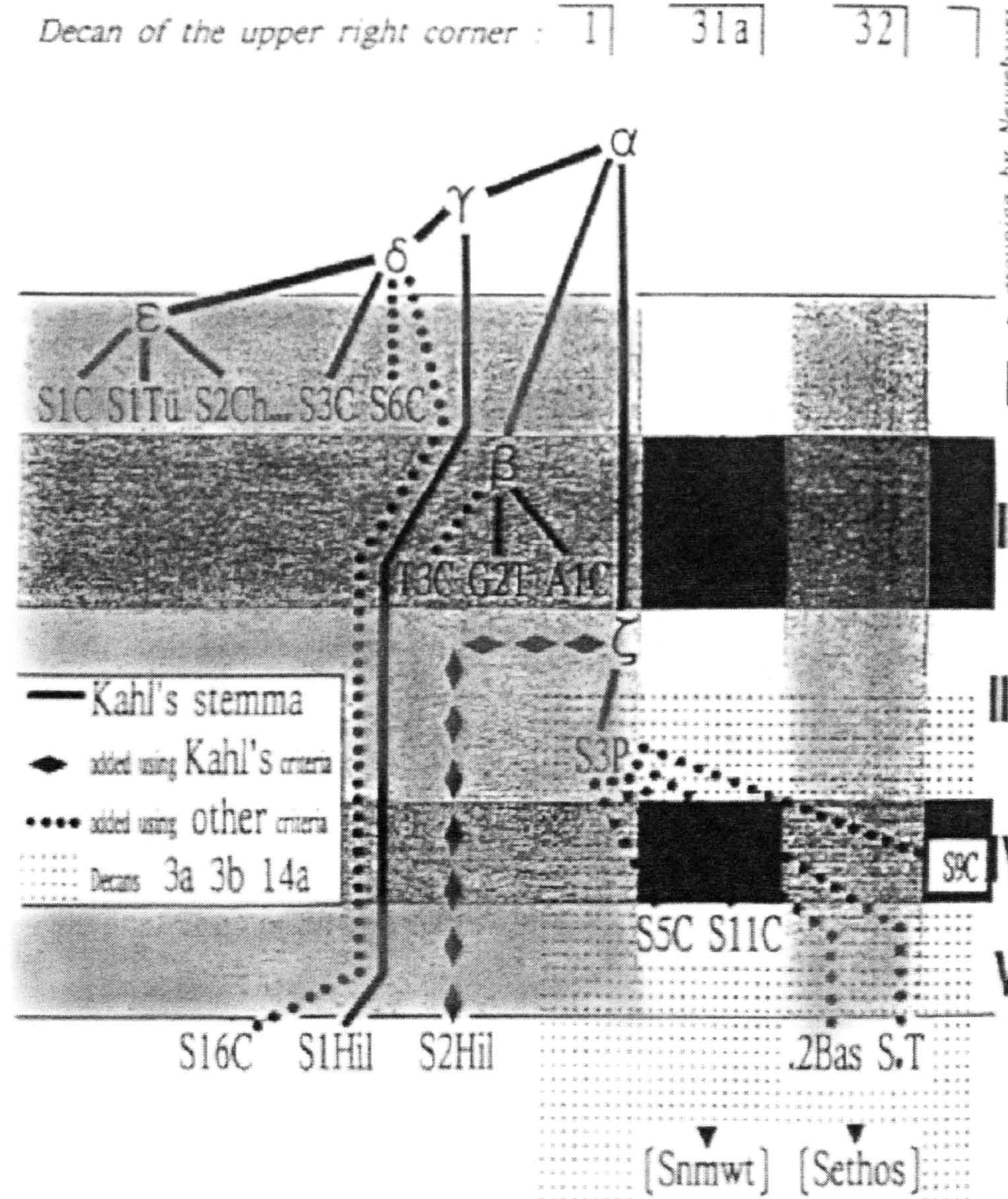


Figure 3: Kahl's stemma superimposed on Neugebauer and Parker's grouping system by Locher
(from Locher 'Middle Kingdom astronomical coffin lids')

Decans in the Star Clock Tables

The aim of analysing decan lists is to attempt to find some information about the antecedents of the tables in order to assess the timekeeping abilities of the star clock, and to understand how this timekeeping method developed. It has been accepted that these coffin lids are not authoritative sources for decan lists because the tables were clearly not understood by the copyists. We must attempt to strip away copying errors, epigraphic confusion, and artistic licence to retrieve the concepts and methods behind these tables.

Neugebauer and Parker list seventy rising star clock decans[19] two of which do not appear in any of the clocks (*ṯs ꜥrḳ*[20] and *sꜣḥ*). The seventy decans and the labels used by Neugebauer and Parker to distinguish them are listed in Table 19. These labels should not be confused with the numbers 1-36 and letters A-M used in Table 1 to introduce the star clock.

1	*ṯmꜣt ḥrt*	12	"crew"	24	*ꜥrt*	35	*ḥꜣt ḫꜣw*
2	*ṯmꜣt ẖrt*	12a	*sšmw*	25	*ẖry ꜥrt*	35a	*ḥꜣt ḏꜣt*
3	*wšt bkꜣt*	13	*k(n)m*	26	*rmn ḥry*	36	*pḥwy ḫꜣw*
3a	*wšꜣtı͗*	13a	*tpy-ꜥ smd*	26a	*rmn ḥry sꜣḥ*	36a	*pḥwy ḏꜣt*
3b	*bkꜣtı͗*	14	*smd srt*	26b	*ṯs ꜥrḳ*	A	*smd rsy*
4	*ı͗pḏs*	14a	*smd*	27	*rmn ẖry*	B	*smd mḥty*
4a	*sšpt*	15	*srt*	27a	*rmn ẖry sꜣḥ*	C	*nṯr ḏꜣ pt*
5	*sbšsn*	16	*sꜣwy srt*	27b	*rmn sꜣḥ*	D	*rmn ẖry*
5a	*tpy-ꜥ ḫntt*	17	*ẖry ḫpd srt*	27c	*sꜣḥ*	E	*ḫꜣw*
6	*ḫntt ḥrt*	18	*tpy-ꜥ ꜣḫwy*	28	*ꜥbwt*	F	*tpy-ꜥ spd*
7	*ḫntt ẖrt*	19	*ꜣḫwy*	29	*ẖrt wꜥrt*	G	*ı͗my-ḫt spd*
8	*ṯms n ḫntt*	20	*ı͗my-ḫt ꜣḫwy*	30	*tpy-ꜥ spd*	H	*ꜣḫwy*
9	*ḳdty*	21	*bꜣwy*	31	*spd*	J	*ḫꜣw*
9a	*spty*	21a	*ḫntw ḥrw*	31a	*tpy-ꜥ knmt*	K	*nṯr ḏꜣ pt*
9b	*spty ḫnwy*	21b	*ḫntw ẖrw*	31b	*štwy*	L	*sꜣbw*
10	"*ḫnwy*"	22	*ḳd*	32	*knmt*	M	*pḥwy sꜣbw*
10a	*ḫnwy*	22a	*sꜣwy ḳd*	33	*sꜣwy knmt*		
11	*ḥry-ı͗b wı͗ꜣ*	23	*ḫꜣw*	34	*ẖry ḫpd n knmt*		

Table 19: List of decan names with Neugebauer and Parker's numbering system

[19] *Egyptian Astronomical Texts* 1 pls. 26-29.
[20] As Neugebauer and Parker noted in their Additions and Corrections to Volume 1 which appeared in *Egyptian Astronomical Texts* 3 p. 272.

		1	2	3	4	5	6	7	8	15	16	17	9	10	11	12	13	14
1	*ṯmꜣt ḥrt*	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X
2	*ṯmꜣt ẖrt*	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
3	*wšt bkꜣt*	X	X	X	X	X	X	X	X	X	X							
3a	*wšꜣti*												X	X	X	X	X	X
3b	*bkꜣti*												X	X	X	X	X	X
4	*ipḏs*	X	X	X	X	X	X	X	X	X	X		X		X			
4a	*sšpt*														X		X	X
5	*sbšsn*	X	X	X	X	X	X	X	X	X	X		X		X			
5a	*tpy-ꜥ ẖntt*													X	X	X	X	X
6	*ẖntt ḥrt*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	*ẖntt ẖrt*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8	*ṯms n ẖntt*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9	*ḳdty*	X	X	X	X	X	X	X	X	X	X		X					
9a	*spty*													X				
9b	*spty ẖnwy*														X	X	X	X
10	*"ẖnwy"*	X	X	X	X	X	X	X	X	X	X	X	X					
10a	*ẖnwy*													X				
11	*ḥry-ib wiꜣ*	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X
12	*"crew"*	X	X	X	X	X	X	X	X		X	X	X					
12a	*sšmw*													X	X	X	X	X
13	*k(n)m*	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X
13a	*tpy-ꜥ smd*														X	X	X	X
14	*smd srt*	X	X	X	X	X	X	X	X		X	X	X					
14a	*smd*												X	X	X	X	X	X
15	*srt*	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X
16	*sꜣwy srt*	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	
17	*ẖry ẖpd srt*	X	X	X	X	X	X	X	X		X		X	X	X	X	X	
18	*tpy-ꜥ ꜣẖwy*	X	X	X	X	X	X	X	X	X	X	X	X	X	[X]	X	X	
19	*ꜣẖwy*	X	X	X	X	X	X	X	X	X	X		X	X	X		X	
20	*imy-ẖt ꜣẖwy*	X	X	X	X	X	X	X	X	X	X	X	X	X				
21	*bꜣwy*													X	X	X	X	
21a	*ẖntw ḥrw*													X	X	X	X	
21b	*ẖntw ẖrw*													[X]	X	X	?	
22	*ḳd*	X	X	X	X	X	X	X	X		X		X	X	X	X	X	
22a	*sꜣwy ḳd*													X		X	X	
23	*ẖꜣw*	X	X	X	X	X	X	X	X		X	X	X		X		X	
24	*ꜥrt*	X	X	X	X	X	X	X	X		X	X	X		X			
25	*ẖry ꜥrt*	X	X	X	X	X	X	X	X	X	X	X	X					
26	*rmn ḥry*	X	X	X	X	X	X	X	X		X		X					
26a	*rmn ḥry sꜣḥ*														X			
26b	*ṯs ꜥrḳ*																	
27	*rmn ẖry*	XΔ																
27a	*rmn ẖry sꜣḥ*														X			
27b	*rmn sꜣḥ*														X			
27c	*sꜣḥ*																	
28	*ꜥbwt*	X	X	X	X	X	X	X	X		X		X					
29	*ẖrt wꜥrt*	X	X	X	X	X	X	X	X		X		X					
30	*tpy-ꜥ spd*	X	X	X	X		X	X	X		X		X					
31	*spd*	X	X	X	X		X	X	X		X		X		X			
31a	*tpy-ꜥ knmt*													X	X	X		
31b	*štwy*														X			
32	*knmt*	X	X	X	X		X	X	X		X		X	X	X	X		X
33	*sꜣwy knmt*	X	X	X			X	X	X		X		X					
34	*ẖry ẖpd n knmt*	X	X				X	X	X		X			X	X	X	X	X
35	*ḥꜣt ẖꜣw*	X	X				X	X	X		X							
35a	*ḥꜣt ḏꜣt*													X	X	X	X	X
36	*pḥwy ẖꜣw*	X	X				X	X	X		X							
36a	*pḥwy ḏꜣt*													X	X	X	X	X
A	*smd rsy*	X	X				X	X	X		X							
B	*smd mḥty*	X	X				X	X	X		X							
C	*nṯr ḏꜣ pt*	X	X				X	X	X									
D	*rmn ẖry*	X	X				X	X	X									
E	*ẖꜣw*	X	X				X	X	X									
F	*tpy-ꜥ spd*	X	X				X	X	X									
G	*imy-ẖt spd*	X	X				X	X	X									
H	*ꜣẖwy*	X					X	X	X									
J	*ẖꜣw*	X					X	X	X									
K	*nṯr ḏꜣ pt*	X					X	X	X									
L	*sꜣbw*								XΔ									
M	*pḥwy sꜣbw*	X					X	X	X									

Table 20: Concordance of decans used in seventeen diagonal star clocks
(grey areas represent damage on original, [X] indicates readable traces, XΔ indicates decan only occurs in epagomenal or list columns)

The decans used in each of the seventeen star clock tables are shown in Table 20. 'X' indicates that a decan is present somewhere in the star clock table. 'XΔ' indicates that the decan only occurs in the epagomenal or list columns of the clock. Grey shading represents parts of the decan list that are missing due to loss or damage, rather than due to omission.

Given that the sources are numbered very approximately according to age, Table 20 gives an indication of developments in the decan list over time. A15, A16, and A17 have been placed after A8 in the table due to the similarities which they share with the first eight sources. Some points of interest are detailed below:

Wšȝt bkȝt splits into two decans in A9, A10, A11, A12, A13, and A14.

Ḳdty and "*ḫnwy*" become or are replaced by *spty* and *ḫnwy* respectively in A10, then merge to a single decan *spty ḫnwy* in A11, A12, A13, and A14, while '*crew*' undergoes a change of writing from A10 onwards.

The decans labelled '13a' to '17' all refer to parts of a constellation called 'Sheep'. *Tpy-ʿ smd* appears in the four sources A11 to A14, while *smd srt* contracts to *smd* from A9 to A14 (both writings appear in A9 itself). The remaining Sheep decans are present throughout.

The four decans '18' to '21' have been placed in the following order by Neugebauer and Parker: *tpy-ʿ ȝḫwy* ('18'), *ȝḫwy* ('19'), *ỉmy-ḫt ȝḫwy* ('20'), and *bȝwy* ('21'). However, in A1 to A9, and A16, *ỉmy-ḫt ȝḫwy* precedes *ȝḫwy* throughout and *bȝwy* is omitted. The surviving decans suggest that this is the case in A15 and A17 also. Neugebauer and Parker state[21] that '*ỉmy-ḫt*' means 'following' and therefore the decan *ȝḫwy* ('19') must be emended to *bȝwy* throughout the main body of the tables, as the difference in writing between *bȝwy* and *ȝḫwy* is only a matter of the type of bird drawn (𓅡 for *bȝ* and 𓅜 for *ȝḫ*). This leaves the order *tpy-ʿ ȝḫwy* ('18'), *ỉmy-ḫt ȝḫwy* ('20'), '*bȝwy*' (written *ȝḫwy* by mistake) in the clocks, with the

[21] *Egyptian Astronomical Texts* 1 p. 23.

unused decan *ꜣḫwy* positioned between *tpy-ꜥ ꜣḫwy* and *ỉmy-ḫt ꜣḫwy*.

Three points argue against this emendation. Firstly, the alleged writing error occurs uniformly across nine sources (including the clearest and least garbled) which span three of Neugebauer and Parker's 'Groups'. This could, however, point to a writing error in a single source used to produce all the tables A1 to A9, A15, A16, and A17.[22] Secondly, in A10 all four decans '18' to '21' appear, with *bꜣwy* written clearly, although the order cannot be restored. Thirdly, the translation offered as evidence for the suggestion is not as certain as Neugebauer and Parker state. *Ỉmy-ḫt* is used in other astronomical contexts[23] and also very commonly in royal contexts, where it has the meaning 'in the entourage of', or 'accompanying'. The word suggests a close association with, but subservience to, the object. It does not preclude the possibility of preceding the object.

Source	Contents of list and epagomenal columns
A1	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 19 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 1 4 A B C D E F G K J M
A6	1 2 3 4 5 7 7 8 9 10 11 12 13 14 15 16 17 18 20 22 24 25 26 28 29 30 32 33 34 35 36 1 31 A B C D E F L K M
A7	1 3 4 5 6 7 8 9 10 11 12 15 16 18 20 19 22 25 26 28 29 30 32 33 34 35 36 1 A C D K M
A8	25 3 4 5 6 7 25 26 10 11 12 13 14 28 16 18 20 19 22 C D 28 29 30 32 29 34 35 36 1 A F A K L M M

Table 21: Contents of the list and epagomenal columns of diagonal star clocks A1, A6, A7, and A8

In the list and epagomenal columns of A1, summarised in Table 21 using Neugebauer and Parker's labelling system, *ꜣḫwy* appears twice, once before and once after *ỉmy-ḫt ꜣḫwy*, but in the other three sources with preserved list columns, *ꜣḫwy* <u>follows</u> *ỉmy-ḫt ꜣḫwy*.

ꜣḫwy and *ỉmy-ḫt ꜣḫwy* also appear in the offering formulae present in the horizontal strips of A1, A2, A7, A8, A19, and A13 with *ꜣḫwy* preceding *ỉmy-ḫt ꜣḫwy*. However, the decanal order in the formulae does not comply with the order in the accompanying table,[24] and so

[22] If this is the case, it is another argument against the system of classification by groups proposed by Neugebauer and Parker.

[23] For example in the dramatic text from the *Book of Nut* which will be extensively discussed in Section F.

[24] Removing formulae and other extraneous labels the order of decans in the horizontal strip is usually *smd rsy, smd mḥty, nṯr ḏꜣ pt, rmn ḥry, spd, ỉmy-ḫt spd, ꜣḫwy, ỉmy-ḫt ꜣḫwy, ḥꜣt ḫꜣw, pḥwy ḫꜣw, ḫntt ḥrt, ḫntt ḫrt*. These decans are organised into pairs by the interspersion of the *ḥtp dỉ* formula, most pairs having two consecutive decans in list order. However, the pair *spd, ỉmy-ḫt spd* are sometimes replaced by *tpy-ꜥ spd, ỉmy-ḫt spd* which are not consecutive, and the overall order of decans does not follow list order.

cannot be used as conclusive evidence of decanal order.

It must surely be preferable to follow the tables themselves, to read decan '19' as *ꜣḫwy* as it is written, and to state that the order of decans propounded by Neugebauer and Parker, *tpy-ꜥ ꜣḫwy, imy-ḫt ꜣḫwy, bꜣwy* should be restored to the order *tpy-ꜥ ꜣḫwy, imy-ḫt ꜣḫwy, ꜣḫwy,* which appears consistently in A1 to A9, and A16.

The Orion decans, labelled '26' to '29' in Table 20, are areas of confusion in decan lists up to Greco-Roman times. They make their first appearance in a timekeeping context on these coffin lids. A1 to A9, and A16 have the following order of decans in the main body of the table: *rmn ḥry, ꜥbwt, ḫrt wꜥrt* (upper arm, *ꜥbwt* sceptre, under or lower leg). The only occurrence of the decan *rmn ḫry* (lower arm) in any of the sources is at the top of the penultimate column of A1, which places it between *rmn ḥry* and *ꜥbwt*. The decan reappears in later decan lists from the New Kingdom onwards.

Decan Lists in A1 to A9, A15, A16, and A17

Clearly, there is cohesion between the decan lists employed in A1 to A8, A15, A16, and A17 with the existing portion of A9 only differing in certain details: *wšꜣt bkꜣt* is split into two decans, *wšꜣti* and *bkꜣti*, and *smd srt* becoming simply *smd*. <u>We shall use the label Θ for the general list of ordinary decans used in A1 to A9, A15, A16, and A17.</u>

A1, A6, A7, and A8 are complete in that they contain thirty-six columns in the main body of the table plus three or four columns listing the decans and giving the decans for the epagomenal days. In each of these tables, only thirty-four individual ordinary decans appear in the main body of the table. The first triangle decan appears where we would expect it from the ideal model (see Table 1). The gap between the final ordinary *pḥwy ḥꜣw* and the first triangle decan *smd rsy* is filled by repetition of the first two decans *ṯmꜣt ḥrt* and *ṯmꜣt ḫrt.*

A2 and A16 also show this feature in their curtailed tables. It would appear that in the original source for the decan list in these tables, only thirty-four ordinary decans and eleven triangle decans appeared, out of a presumed thirty-six ordinary decans and twelve triangle decans. Of the two ordinary decans and one triangle decan that Θ lacks which would be required to produce a complete, working clock like that of Table 1, the unique appearance of *rmn ḫry* in the list columns of A1 hints that this decan could be one of the missing ordinary decans. *S3bw* makes two similar appearances in the list columns of A6 (where it appears between *tpy-ʿ spd* and *nṯr d3 pt*) and A8 (between *nṯr d3 pt* and *pḥwy s3bw* which would seem to be the correct order) and is a candidate for the missing triangle decan.

Although Neugebauer and Parker postulated that their decan '21' *b3wy* should appear in sources A1 to A9, this decan would replace decan '19' and so would not add to the total number of decans used. Neugebauer and Parker state that they believed a correctly written *3ḫwy* to be one of the two missing ordinary decans, but do not provide any evidence for this addition to the lists of A1 to A9. It is possible, however, that the second occurrence of the name *3ḫwy* in the list columns of A1 could be a single writing error for *b3wy*. If this is the case, the list columns of this source give a complete list of ordinary decans for Θ. If this writing error is not accepted, the remaining missing ordinary decan has left no other evidence to suggest its identity.

Decan Lists in A10 to A14

Sources A12 and A13 both have *ḫry ḫpd n knmt* at the top of the column for the third decade, indicating a closeness in age, and also a major revision of the table since A9. A14 has only eight rows, which makes it difficult to determine the intended positions of the decans, however, the surviving decans agree entirely with A13 and the table is well ordered. A13 includes *sšpt* and *3ḫwy*, which are omitted in A12, but the existing parts of the decan lists otherwise agree.

The table in A10 is jumbled[25] and like A14 only contains four rows, but the decans used agree with those of A12 with three exceptions. Firstly, *spty ḫnwy* is split into *spty* and *ḫnwy* (the only occurrence of these decans on coffin lids), secondly, *tpy-ʿ smd* is omitted, and thirdly *ꜣḫwy* is included.

Like A12 and A13, A11 has *ḫry ḫpd n knmt* at the top of the third column, but has diagonals from top right to bottom left, the reverse direction to that normally employed. The list used draws elements from both Θ and the lists of the four sources A10, A12, A13, and A14, and is the only list to retain the decans *ʿrt, rmn ḥry sꜣḥ, rmn ḫry sꜣḥ, rmn sꜣḥ,* and *spd.* The second and third of these may be the same as *rmn ḥry* and *rmn ḫry*,[26] but the fourth is unique among these seventeen sources.

We shall attempt to construct a general list of ordinary decans from the lists of A10, A11, A12, A13, and A14 which we hope will resemble the original source material used in the construction of these five sources. We shall label this list Φ. It will not be as straightforward to construct Φ as it was to compile Θ due to the incompleteness and confusion within the five sources A10 to A14.

Twenty-four ordinary decans can be placed with certainty into Φ. Twenty-one of these decans appear in the four sources A10 to A13 and in the surviving portion of A14 (see Table 20), one (*tpy-ʿ ꜣḫwy*) appears clearly in A10, A12, and A13 with traces readable in A11, and two (*tpy-ʿ knmt* and *knmt*) are missing from A13 due to being in a portion of the table which has not survived but can be restored with some degree of certainty. These twenty-four

[25] *Egyptian Astronomical Texts* 1 p. 18 fig. 12.
[26] See errata to *Egyptian Astronomical Texts* 1 in *Egyptian Astronomical Texts* 3 where Neugebauer and Parker state that they had revised their opinion of this problem to suggest that *rmn ḥry/ḫry* and *ḥry/ḫry rmn* were in fact four distinct decans.

decans form the core of Φ.

We must now attempt to reconstruct as much of the remainder of Φ as we can. We shall rely mostly upon A10, A12, A13, and A14, but where these decan lists break off we must use information from the disordered A11. After considering which decans might belong in Φ, we shall discuss the value of the list which we have created.

Discussion of the remaining decans in Φ can be broken into six problems:

1) Decans included in three of the four sources: *tpy-ꜥ smd* (missing in A10), *ḫntw ḫrw* (traces in A10 and probably present in A13), and *sꜣwy ḳd* (missing in A11). We include *ḫntw ḫrw* in Φ with certainty because of its strong association with its pair *ḫntw ḥrw* and traces of the decan being visible in A10. The other two decans are present in the most coherent sources A12, A13, and A14 so we also include them in Φ.

2) *Sšpt* is included in three lists, A11, A13, and A14. Neugebauer and Parker (working without knowledge of A13 or A14) considered it to be an out of place triangle decan along with *ỉpḏs* and *sbšsn*, due to the disordered nature of A11. However, its inclusion in the orderly sources A13 and A14 must bring their interpretation into question, and raise the possibility of its inclusion in Φ as an ordinary decan.

3) The split of *spty ḫnwy* which occurs in A10 appears again in later decan lists and will also be noted in connection with those lists.[27] The other four sources do not split *spty ḫnwy* so we shall follow them in placing it as one decan in Φ.

4) The *ꜣḫwy* decans: *ỉmy-ḫt ꜣḫwy* and *ꜣḫwy*. *ꜣḫwy* is omitted only in A12 (it is in the missing portion of A14) and seems likely to be an ordinary decan belonging to Φ, but *ỉmy-ḫt ꜣḫwy* occurs only in A10. It is possible that this decan is an out of place triangle decan or is poorly written, but neither of these explanations is entirely satisfactory as there are no other

[27] See Section H.

obvious intrusive triangle decans in A10 and the inclusion of '*ỉmy-ḫt*' is a strange mistake. We therefore include *ꜣḫwy* in Φ but reject *ỉmy-ḫt ꜣḫwy*, both with reservations. We included *bꜣwy* in Φ due to its occurrence in all four sources, but it must be noted that its appearance in A13 only consists of traces in one cell and possibly is a badly written *ꜣḫwy*.

5) The Orion decans: we have no alternative but to consider A11 from *ḫꜣw* (which also appears in A13) onwards as our model. This adds to Φ up to six decans: *ḫꜣw* and *ꜥrt* (both of which also appear in Θ), *rmn ḥry sꜣḥ* and *rmn ẖry sꜣḥ* (which could be equivalent to *rmn ḥry* and *rmn ẖry* in Θ), *rmn sꜣḥ*, and *spd*. We are reasonably comfortable with *ḫꜣw*, *ꜥrt*, *rmn ḥry*, and *spd* and include them in Φ, but we have not met *rmn sꜣḥ* before and *rmn ẖry* was only a possible inclusion in the list of ordinary decans in Θ. A decan may be both an ordinary decan and a triangle decan in the same list: *ḫꜣw*, *tpy-ꜥ spd*, and *ꜣḫwy* appear in both roles in Θ and *rmn ẖry* was also a triangle decan belonging to Θ. It is possible that either, both, or neither *rmn sꜣḥ* and *rmn ẖry sꜣḥ* are ordinary decans. It is impossible to decide which of these possibilities to accept.

6) The inclusion of misplaced triangle decans in the list of A11: *ỉpḏs*, *sbšsn*, *rmn ẖry sꜣḥ*, *rmn sꜣḥ*, and *štwy*. We have already discussed *rmn ẖry sꜣḥ* and *rmn sꜣḥ* above. The other three seem reasonably certain to be triangle decans because they occur in parts of the list that are well preserved in the other three sources.

Having discussed each area of difficulty individually, we have now chosen a framework for Φ consisting of:

twenty-four 'certainties'

+ *tpy-ꜥ smd* + *ḫntw ḥrw* + *sꜣwy ḳd* (see point 1 above)

+ *sšpt* (possibly, point 2)

+ *spty ḫnwy* (point 3)

+ *3ḫwy* (possibly, point 4)

+ *ḫ3w* + *ʿrt* + *rmn ḥry s3ḥ* + *rmn ḫry s3ḥ* (possibly a triangle decan)

+ *rmn ḥry* (also possibly a triangle decan) + *spd* (all from point 5)

Rather conveniently, this makes a possible total of thirty-six.

We now must face three alternatives: either a) our list Φ is complete and correct, or b) some or all of our 'possibles' are incorrect and must be replaced, or c) the five sources A10, A11, A12, A13, and A14 do not form a coherent group and a single list cannot be assembled from the decan lists preserved in each individual source.

The first alternative is unlikely to be true. Given that we have only four sources, all of them being incomplete and two of them having serious problems in their layout, it would be unrealistic to suppose Φ to be definitive; that is, that the contrived list Φ as presented above is an accurate reconstruction of an Egyptian decan list on which coffin lid star clocks were based. The most likely situation would be that A11 is missing some 'Orion' and/or other decans, and some 'possibles' are misplaced triangle decans or mistakes.[28] This conforms to the second alternative, which can also be satisfied by including some decans which appear only in A10 as ordinary decans (*spty*, *ḫnwy*, and/or *imy-ḫt 3ḫwy*) with some 'possibles' again being triangle decans.

The third alternative must be realistically faced. While the decan lists from A1 to A8 are clearly of the same nature, and allied closely to the list of A9, several dissimilarities occur between the lists of the five sources A10 to A14. The disorder in A11 makes it difficult in the extreme to base theories soundly on evidence gathered from this source, but A10, A12, A13, and A14 do agree reasonably closely with each other. We have already noted the similarity between the decan lists of A10 and A12, and the lists of A13 and A14, and that the

[28] See Section H, where the inclusion of *sšpt* will be reviewed with reference to later decan lists.

two omissions in the decan list of A12 that occur in comparison with that of A13 are the only differences between those lists.

Generally, the five sources display the same major features in their decan lists and seem to have been designed from a similar source. A10 retains certain distinct features, and the Orion area holds the greatest uncertainty.

The decan list of A9 displays two features from Φ, the splitting of *wšt bk3t* the writing of the decan *smd* with a single occurrence of *smd srt*.

In summary, we have identified two basic decan lists. We theorise that A1 to A9, A15, A16, and A17 were created using a decan list resembling our list Θ, and that a later list to which our list Φ is an approximation was used as a basis for A10 to A14. The two lists Θ and Φ are presented with brief annotations in Table 22, with disputed or difficult decans shaded. *Spd* is placed last in the two lists to aid comparison.

Comparing Θ and Φ side by side, we see that the two lists have nineteen decans in common, with names matching exactly, and four decans whose names are written differently but which could refer to the same stars. Of the remaining thirteen decans, there is a possible correspondence between *ḥ3t* and *pḥwy ḫ3w* in Θ and *ḥ3t* and *pḥwy ḏ3t* in Φ. The omission of '*srt*' from the decan *smd srt* in the later sources has been discussed previously. One of Θ's decans, *wšt bk3t*, is split into two decans in Φ.

We shall use Table 22 later to discuss possible revisions of the star clock tables, and our analysis of decan lists in the seventeen sources will also be in Section H useful in our discussion of decan lists within celestial diagrams. We have divided our sources into two traditions, each of which retains a degree of flexibility, rather than stringently discriminating between sources which display slight dissimilarities. This is a rather looser approach than that proposed by Kahl, but seems more in keeping with the nature of the sources (being copies for symbolic purposes rather than observational records or primary timekeeping devices). Our findings reflect trends rather than a strict classification system, and the ability of the two lists we have created to include the more recently published sources is an indication that this approach is more likely to continue to be useful if more sources are discovered.

Θ		Φ	
knmt		*tpy-ʿ knmt*	Restored in A13
s3wy knmt		*knmt*	Restored in A13
ḥry ḫpd n knmt		*ḥry ḫpd n knmt*	
ḥ3t ḫ3w		*ḥ3t ḏ3t*	
pḥwy ḫ3w		*pḥwy ḏ3t*	
ṯm3t ḥrt		*ṯm3t ḥrt*	
ṯm3t ẖrt		*ṯm3t ẖrt*	
wšt bk3t	Split in A9	*wš3ti*	
ipḏs		*bk3ti*	
sbšsn		*šspt*	Omitted in A10 and A12
ḫntt ḥrt		*tpy-ʿ ḫntt*	
ḫntt ẖrt		*ḫntt ḥrt*	
ṯms n ḫntt		*ḫntt ẖrt*	
ḳdty		*ṯms n ḫntt*	
"*ḫnwy*"		*spty ḫnwy*	Split into *spty* and *ḫnwy* in A10
ḥry-ib wi3		*ḥry-ib wi3*	
"*crew*"		*sšmw*	
k(n)m		*k(n)m*	
smd srt	Becomes *smd* in A9	*tpy-ʿ smd*	Omitted in A10
srt		*smd*	
s3wy srt		*srt*	
ḥry ḫpd srt		*s3wy srt*	
tpy-ʿ 3ḫwy		*ḥry ḫpd srt*	
imy-ḫt 3ḫwy		*tpy-ʿ 3ḫwy*	Traces in A11
3ḫwy		*3ḫwy*	Not in A12
b3wy	Very tentatively one of the two missing ordinary decans	*b3wy*	
ḳd		*ḫntw ḥrw*	
ḫ3w		*ḫntw ẖrw*	Traces in A10 and possibly A13
ʿrt		*ḳd*	
ḫry ʿrt		*s3wy ḳd*	Omitted in A11
rmn ḥry		*ḫ3w*	Only survives in A11 and A12
rmn ḫry	Possibly one of the two missing ordinary decans	*ʿrt*	Only known from A11
3bwt		*rmn ḥry s3ḥ*	Only known from A11
ḫrt wʿrt		*rmn ḫry s3ḥ*	Only known from A11, possibly a triangle decan
tpy-ʿ spd		*rmn s3ḥ*	Only known from A11, possibly a triangle decan
spd		*spd*	Only known from A11

Table 22: Decan lists Θ and Φ

A Model Star Clock

In order to illustrate the problems which arise when attempting to analyse rising star clock tables, let us imagine the construction of a new star clock. For this simplistic illustration, we assume that the necessary concepts of observation and timekeeping are already within our grasp, and that we understand completely the instrument which we are trying to construct.

On the first day of the first month of the season Akhet, at the first hour of the night, we look at the eastern horizon, and write down the name of a bright star just rising. We wait one hour, then look again and find another bright star rising. We continue in this manner until the twelfth hour. At the end of the night, we have a list of twelve stars. These form the first column of a diagonal star clock when headed with the date.

Ten days later, on the eleventh day of the month, we follow the same method of observation. This time, we notice that the star which had marked the second hour will now be the first to appear. Similarly, the star which marked the third hour will now appear in the second, and so on until a new star will need to be chosen for the twelfth hour. We use this list as the second column in the star clock.

If the year contained exactly 360 days, continuing observations at ten day intervals would produce a clock of thirty-six columns, using a decan list of exactly thirty-six stars. The clock would be sufficient to obtain the hour of the night, and would only be made inaccurate after enough time had passed for the effects of precession to affect the clock.

The Egyptian civil year was of 365 days, comprising twelve months of three decades each, plus five epagomenal days or 'days upon the year'. What this means for the star clock is that the first decan in the table does not mark the twelfth hour in the 26th decade (I Shemu Middle decade) as would occur with a 360-day year. A new star will have to be chosen. This star will be a triangle decan and will lie approximately half way between the last and first ordinary decans.[29]

[29] For a graphical representation and explanation see *Egyptian Astronomical Texts* 1 pp. 108-109 figs. 30, 31, 33.

For each subsequent decade, a new triangle decan will be added to the list, until, during the five epagomenal days, the twelve triangle decans will mark the hours of the night. On the first day of the new year, the first twelve ordinary decans will then come back into use, because there is only a five-day gap between the first epagomenal day and the first day of the first month of Akhet.

This model produces an ideal rising star clock table in the form of Table 1.

Using the numbering scheme of Table 1 (which is not equivalent to the numbering of decans used by Neugebauer and Parker and repeated here in Table 19, but is used as a convenient system for describing a general clock) the order of rising of the decans used would be A, 1, B, 2, C, 3, D, 4, E, 5, F, 6, G, 7, H, 8, J, 9, K, 10, L, 11, M, 12, 13, 14, through to 34, 35, 36 followed by A, 1, etc. again.

The solar year is not 365 days long exactly. The quarter of a day per year by which the Egyptian civil year lagged behind the solar year means that the star clock table remains 'reasonably' accurate for only twenty civil years.[30] After that time, Neugebauer and Parker contend,[31] many new decans would have to be chosen if the clock was to be kept up to date. Twenty years is sufficient to cause decan 1 instead of decan B to mark the second hour of the night on the first epagomenal day. This means that the final column of the table would be inaccurate twenty years after the table was constructed. Decan 2 would replace decan C, decan 3 would replace decan D and so on, until the twelfth hour would be marked by decan 11.

Neither decan 36 nor decan A would be exactly correct for marking the first hour. A new decan would have to be found between decan 36 and decan A, which Neugebauer and Parker

[30] *Egyptian Astronomical Texts* 1 p. 108.
[31] *Egyptian Astronomical Texts* 1 p. 109.

labelled 'decan 36a'.

Neugebauer and Parker suggest that reorganisation of the entire table, not just the epagomenal column, would be needed twenty years after the construction of the star clock. This would mean replacing each decan in the main body of the table. Decan 1 would be replaced by decan A throughout, similarly, the other decans 2 to 12 would be replaced by decans B to M. Decan 13 would be replaced by a new decan, which rose halfway between decan 12 and decan 13. Neugebauer and Parker label this new decan 'decan 12a'. The subsequent decans 14 to 36 would all be replaced, using the new decans Neugebauer and Parker call 13a to 35a. Decan A would be replaced by decan 36a and finally, decans B to M would be replaced by decans 1 to 11, just like the decans in the epagomenal column.

The new table would therefore require the choice of twenty-five new decans. The order of rising of the decans would be A, 1, B, 2, C, 3, D, 4, E, 5, F, 6, G, 7, H, 8, J, 9, K, 10, L, 11, M, 12, 12a, 13, 13a, 14, 14a through to 34a, 35, 35a, 36, 36a, A, 1, etc.

After another twenty civil years had passed, the epagomenal column would once again be out of date. Decan 36 would rise at the beginning of the first hour and the epagomenal column would have to be rewritten as 36, A, B, C, D, E, F, G, H, J, K, L.

The main body of the table, if corrected at the same time, would then be subject to another 'half-decan shift' with decan B being replaced with decan 1 and so on. This new table resembles the original star clock table of forty civil years earlier very closely. The only difference is that a new decan, 36a, now marks the first hour of the first decade of the year, and all other decans are shifted along diagonally. Decan M does not appear anywhere in the table.

The process of updating the clock at twenty civil year intervals would continue to keep this timekeeping method viable over the centuries, using a total of seventy-three decans.[32]

It is questionable whether the total revision of the table after twenty years would be necessary. The epagomenal column would be incorrect, but the main body of the clock would still be correct within a time scale of ten days without revision.

While Neugebauer and Parker's revision cycle described above is technically necessary to maintain a workable star clock, we need to compare the theory of a twenty year revision cycle, and of a forty year revision cycle, with the existing sources to find out whether such methodical refinement was indeed utilised, and if not, what sort of revisions did take place and on what basis they were made.

Comparison of Revision Scheme with Existing Star Clocks

Of the seventeen sources that we are considering, we can see that A1 to A9, and A16 (and probably A15 and A17 as well had this portion of the tables been preserved) all have *ṯmꜣt ḥrt* as the first hour of the first decade of the year. A1 to A8 and A16 provide no evidence among themselves for adjustment of the clock over time. We shall label the year in which the original source for A1 to A8 was produced 'year *n*'. A15 is only partially preserved and only ten rows are included in A17, but it seems likely that these tables derive from the same source.

A9 contains a small modification when compared to the year *n* tables. The third decan *wšt bkꜣt* has been split into two decans *wšꜣtl* and *bkꜣtl*. This means that although decans *ṯmꜣt ḥrt* and *ṯmꜣt ẖrt* remain in the same positions as in the year *n* table, *ỉpḏs* and all following decans are shifted along. The only other change in A9 is the writing of *smd srt* as *smd* which has already been discussed.

[32] That is, 1 to 36 (36 decans) plus A to M (12 decans, as I is omitted) plus 12a to 36a (25 decans) making 73 decans.

There are two possible explanations for the split of the decan *wšt bkȝt*: copying error or deliberate reorganisation of the decan list. The first would be caused by either the copyists of the other sources (or the copyist of the prototype for the sources) mistaking the name of two decans for one (this would mean that one of the two 'missing' ordinary decans of Θ discussed previously would be *bkȝti*) or the copyist of A9 splitting a single decan into two and propagating the shift throughout the table which the error caused. The second possibility implies that the split occurred in an effort to update the table. A shift of one extra decan means that this correction would have occurred around year $n + 40$. *Ṯmȝt ḥrt* and *ṯmȝt ẖrt* may have been kept as the first two decans because of tradition.

The decan of the first hour of the first decade of the year is difficult to ascertain in A10, A11 and A13, but A12 and A14 provide clearer information. In both cases, *ṯmȝt ḥrt* has shifted along to mark the first hour in the sixth decade with a new decan *tpy-ʿ knmt* occupying the first cell in A12. The position of *ṯmȝt ḥrt* indicates a date of $n + 200$ years. The four decans between *tpy-ʿ knmt* and *ṯmȝt ḥrt* are *knmt*, *ẖry ḫpd n knmt*, *ḥȝt ḏȝt*, and *pḥwy ḏȝt*. It is possible that *ḏȝt* is either a new name for the constellation *ḫȝw* that appears in A1, A2, A6, A7, A8, and A16 in the same position in the decan list, or that two new decans have replaced *ḥȝt ḫȝw* and *pḥwy ḫȝw*, which are coincidentally another pair of *ḥȝt* and *pḥwy* (forepart and hindpart) stars. This implies an order *ḥȝt ..., ḥȝt ..., pḥwy ..., pḥwy ...* which is not impossible if the decans do not lie on a belt, but are chosen for their rising times only.

After *ṯmȝt ḥrt* and *ṯmȝt ẖrt* A12, A13, and A14 have the decans *wšȝti* and *bkȝti*. A13 and A14 then include *sšpt*, which does not appear in A12 but does appear in the disordered A11. The inclusion of *sšpt* leaves the remainder of the table of A12 out of step with A13 and A14. A date of $n + 240$ is therefore also possible for A13 and A14. The dates discussed are summarised in Table 23.

Source	Year
A1 to A8, A15, A16, and A17	*n*
A9	*n* or *n + 40*
A10	*?*
A11	*?*
A12	*n + 160* or *n + 200*
A13 and A14	*n + 200* or *n + 240*

Table 23: Date scheme for diagonal star clocks A1 to A17

None of the sources shows the major change in decans that would have occurred in year *n + 20*, *n + 60* etc. Although it is possible that additional sources may be found that conform to the pattern of revision twenty years after *n* or multiples of forty years after that, the current information leads to the conclusion that this intermediate revision did not take place.

The revision process as seen in the seventeen sources was more conservative and observationally-based than Neugebauer and Parker suggest. We see that some ordinary decans were also used as triangle decans within the same decan list,[33] indicating that suitable intermediate decans were sometimes unavailable. We also notice that decans were sometimes inserted or removed disturbing the list,[34] but this seemed to be acceptable to the compilers. Comparing the two lists Θ and Φ reveals that certain decans which are common to both appear at different intervals in each list.[35] This could indicate that some or all decan names may refer to a group of stars rather than to just one single star, so that time would elapse between the rising of the first stars of the asterism and the final stars leading to differing intervals from list to list.

These factors indicate that the revisions were not achieved methodically by substitution of each decan for another as described in the demonstration above, but probably had an observational basis which was subject to human and observational factors, and to such

[33] For example *tpy-ˁ spd* in Θ.

[34] Such as the splitting of *wšt bkꜣt* into two decans.

[35] For example, there is a decan (*sꜣwy knmt*) between *knmt* and *ḫry ḫpd knmt* in Θ but not in Φ.

pressures as certain decans being aesthetically or symbolically favoured, and the weight of tradition.

That the star clocks evidently were updated means that the tables were a sufficiently important timekeeping method with usefulness or symbolism that merited being kept somewhat current over several generations.[36] For this reason, they remain of prime importance in the history of stellar timekeeping in Egypt. Furthermore, the survival of the decans as a recognised group to the end of Egyptian religion signifies that their importance as a group of objects or as a symbolic concept was never forgotten.

Dating the Star Clocks

The positions of Sirius (*spd*) in the tables lead Neugebauer and Parker[37] to date the origin of the decan lists used on the coffin lids as shown in Table 24. The lists seem to have been compiled only shortly before they were used on the painted coffin lists.[38]

Group	Date of Sirius as the 12th hour star	Date BC	Dynasty
I (A1-5)	II Peret 21 or III Peret 11	2150-2100 2070-2020	IX-X
II (A6-8)	II Peret 21 or III Peret 11	2150-2100 2070-2020	XI
III (A9)	III Peret 1	2110-2060	
IV (A10)	?		
V (A11,12)	assume IIII Peret 21	1910-1860	XII

Table 24: Dates of the star clock tables according to Neugebauer and Parker

It is obvious from the table above that the occurrences of Sirius in the tables do not provide a basis on which to date the tables on the time scale of forty years. We cannot, therefore, give a definite value for n, but estimate it to be between 2150 and 2020 BC.

Table 23 suggests that, apart from the dating difficulties caused by omission or inclusion of

[36] Borchardt *Die Zeitmessung* p. 8. A Ptolemaic water-clock inscription states that the instrument was used when decans were not visible.
[37] *Egyptian Astronomical Texts* 1 p. 31.
[38] In Section H, we will see that the preserved triangle decans relating to list Θ are probably considerably older than the list of ordinary decans with which they appear on the early coffin lids.

certain single decans, the decan lists we have considered so far fall into two clusters of dates: *n* to *n + 40*, and *n + 160* to *n + 240*. This spread of dates agrees with Neugebauer and Parker's estimates for the decan lists as shown in Table 24.

We must now apply what we have learned about the composition of the early star clocks to the problem of understanding the decan lists which were used in timekeeping contexts during the New Kingdom, their purpose, and relationship to the earlier lists.

Section B: New Kingdom Star Clocks

Introduction

Decan lists in a setting indicating a timekeeping use are rare after the First Intermediate Period. Only three such occurrences are known dating from the New Kingdom, two of them clearly of the same derivation.

Sources

B1 Star clock on the ceiling of the Sloping Passage in the Osireion at Abydos[39]

B2 Vignette from the *Book of Nut*, ceiling of the Sarcophagus Chamber in the Osireion at Abydos[40]

B3 Vignette from the *Book of Nut*, ceiling of the Sarcophagus Chamber in the Tomb of Ramesses IV (KV2)[41]

The Osireion Star Clock

A fragment of a star clock table B1 survives on the soffit of a lintel in the Osireion complex (Figure 4). The contents and disposition of the table have been described by Neugebauer and Parker. A schematic diagram of the surviving part of the table is shown in Table 25.

The third column of Table 25 is headed by a month name 'I Peret' and the label 'Hour Name'. In the six cells below, the first six hours of the night are listed:

Her first period[42] of *ḫ3wy*[43]
Her second period in *bk3t*
Her third period in *bk3t*
Her fourth period in *bk3t*
She/her ?[44] *wš3w*
Her beautiful period in *wš3w*

---

[39] *Egyptian Astronomical Texts* 1 pp. 32-35.

[40] *Egyptian Astronomical Texts* 1, Chapter II, Frankfort *The Cenotaph of Seti I*, Murray *The Osireion at Abydos*.

[41] *Egyptian Astronomical Texts* 1, Chapter II.

[42] The word *sp* and not *wnwt* in this and the cells below. The use of *wnwt* to denote hours of the night is, however, known from the *Pyramid Texts* (Utterance 251 269a, Utterance 320 515a) from which Parker (*Ancient Egyptian Astronomy*) infers that stellar timekeeping was established by the 24th century BC. He also notes that the division of the night into twelve hours is not confirmed until 2150 BC, refering to the date of the earliest diagonal star clock tables, although it must be remembered that neither the word *wnwt* nor the word *sp* appears in a star clock table from that date.

[43] The words *ḫ3wy*, *bk3t* and *wš3w* are words for various parts of the night.

[44] Neugebauer and Parker suggest *ḳm3* 'creates'.

First decade	* s3pty	* ḫnwy	* ḥry-ib wi3	* šsmw	* knmw	* tpy-ˁ smd
I Peret Hour Name	sp=s n ḫ3w	sp 2=s m bk3t	sp 3=s m bk3t	sp 4=s m bk3t	?=s wš3w	sp=s nfr m wš3w
Second decade	ḫnwy *	ḥry-ib wi3 *	šsmw *	knmw *	tpy-ˁ smd *	smd *
Third decade	ḥry-ib wi3 *	šsmw *	knmw *	tpy-ˁ smd *	smd *	srt *

Table 25: Layout of the star clock in the Sloping Passage of the Osireion

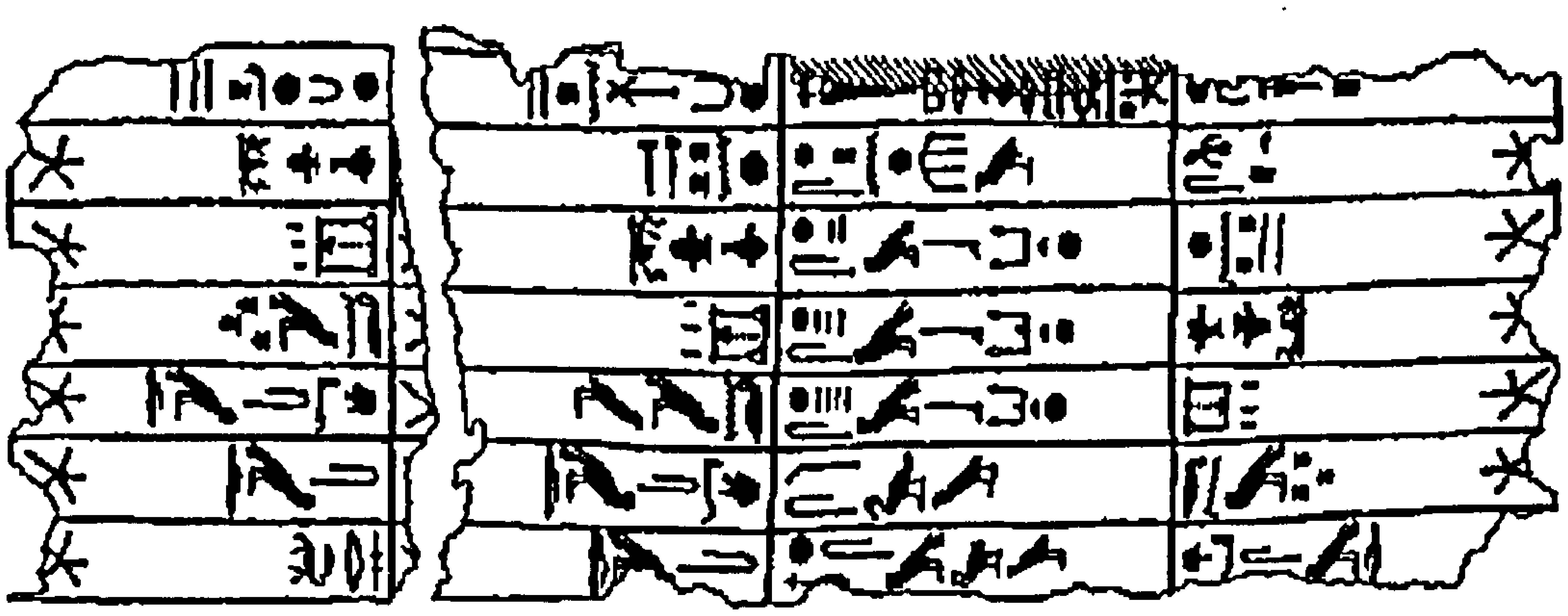


Figure 4: Star clock in the Sloping Passage of the Osireion
(from *Egyptian Astronomical Texts* 1)

Neugebauer and Parker show that this table is of the same nature as the diagonal star clocks discussed previously, but arranged differently. Eight decans are used and can be placed in order by following Neugebauer and Parker's rearrangement of the Osireion clock into diagonal star clock table format. In Table 26 we compare the decans used in B1 with those in lists Θ and Φ.

B1 and Θ have obvious dissimilarities, due to writings (*knmw* and *k*(*n*)*m*) or different names which we presume represent the same object (*ḫnwy* and "*ḫnwy*", *šsmw* and "*crew*", *s3pty* and *ḳdty*, *smd* and *smd srt*) or the more fundamental difference of the omission of *tpy-ᶜ smd*.

Φ also displays some writing differences compared with B1, *sšmw* as opposed to *šsmw* and *k(n)m* instead of *knmw*. The major disparity between the Osireion list and Φ is the separation of *s3pty* and *ḫnwy* into distinct decans. A10 also differs from the general list Φ by splitting this decan, but also omits *tpy-ᶜ smd*.

B1	Θ	Φ
s3pty	*ḳdty*	*spty ḫnwy*
ḫnwy	"*ḫnwy*"	
ḥry-ib wi3	*ḥry-ib wi3*	*ḥry-ib wi3*
šsmw	"*crew*"	*sšmw*
knmw	*k(n)m*	*k(n)m*
tpy-ᶜ smd	-	*tpy-ᶜ smd*
smd	*smd srt*	*smd*
srt	*srt*	*srt*

Table 26: Comparison of decans from the Sloping Passage star clock with those from early sources

The small portion of the list which survives is enough to suggest that the Osireion clock shares more features in common with A10 to A14 than with the Θ-based clocks A1 to A9, A15, A16, and A17.

Date of the Decan List of B1

Since *ḥry-ib wi3* appears in all the coffin lid tables except A15 as well as in the list from B1 we shall use this decan to summarise in Table 27 the dates of the decan lists we have dealt with so far. We find that B1 appears to be contemporary with A12. However, Neugebauer and Parker base their dates on the behaviour of Sirius. To obtain a date for B1, they estimated that *spd* would appear as the twelfth hour of IIII Peret Middle Decade, and so date the Osireion sloping passage list as being slightly earlier than A12, that is from the beginning to the middle of the XIIth dynasty.

The Osireion is attributed to Seti I, but the star clock B1 was painted during the reign of Merneptah (1224-1214 BC). Our estimate of *n* (2150 to 2020 BC) means that the decan list used was more than 600 years out of date. This discrepancy indicates the archaism present in the construction and decoration of the Osireion complex. What we do not know is whether the diagonal star clock was still used for timekeeping (either symbolically or practically) and was still being updated in the New Kingdom. The difference in layout between the Sloping Passage star clock and the coffin lid star clocks could indicate that the tables were still well enough understood in the New Kingdom to allow such a transformation to be carried out, but of course the layout may also date back to the Middle Kingdom.

Source	Position of *ḥry-ib wi3*	Year
A1 to A8, A16	III Akhet, Last Decade, Third Hour	*n*
A17	Only has ten rows	?
A9	IIII Akhet, First Decade, Third Hour	*n+40*
A10	Disordered	?
A11	Disordered	?
A12	I Peret, First Decade, Third Hour	*n+160*
A13	I Peret, Middle Decade, Third Hour	*n+200*
A14	Only has eight rows	?
B1	I Peret, First Decade, Third Hour	*n+160*

Table 27: Summary of dating scheme for decan lists

It is more likely that the choice of a six-hundred year old decan list indicates that this was the oldest available source, and that the timekeeping method was considered sufficiently venerable and arcane to be included in the complex, which may mean that diagonal star clock tables, at least in the form that we have studied, had not been used for some time.

Decan Lists in the *Book of Nut*

The *Book of Nut* is a religious text of which the earliest surviving example occurs in the New Kingdom on the ceiling of the Sarcophagus Chamber[45] of the Osireion (Figures 25 and 26 in Section F, which discusses the text in detail). Part of the text also occurs in the tomb of Ramesses IV in the Valley of the Kings (Figure 27), and Papyri Carlsberg I and 1a dating from the second century AD.

[45] The entire room represents a sarcophagus (hence the two large Nut goddesses on the ceiling, a characteristic design for the internal surface of sarcophagi). See Frankfort *The Cenotaph of Seti I* p. 27.

The main graphical feature of the text is a picture of the sky-goddess Nut being raised by her father, the god Shu, who is portrayed centrally. A decan list is written on the body of Nut in short vertical columns reading from her shoulders to her hips. In each column, one or more decan names are written followed by a star (★ N14). Under each column, below the limit of the dividing lines, a number of circles appear denoting the number of stars associated with the decan(s). We shall call this decan list α.

In the space between the body of the goddess and the ground, a list occurs in vertical columns. Each entry in the list consists of three dates separated by three labels. Some entries belonging to the list also appear on the arm of the goddess and above a wavy line denoting sand. Some names of decans are associated with these extra entries, and other decanal names appear as labels in other parts of the vignette. We shall call the list to which all these decans belong β.

α	Star circles	α	Star circles
tpy-ˁ knmt	3	*s3wy srt*	4
knmt	6	*ḥry ḫpd srt*	1
ḥry ḫpd n knmt	1	*tpy-ˁ 3ḫwy*	2
ḥ3t d3yt	3	*3ḫwy*	4 (B2) 3 (B3)
pḥ d3yt	3	*b3wy*	5
tm3t ḥrt + tm3t ḫrt	7 (B2) 3 (B3)	*ḫnt ḥr*	3
wš3ti	2	*ḥry-ib ḫnt*	3[46]
bk3ti	1	*ḫnt ḫr*	1
sb3w mḥw	3	*ḳd*	3
tpy-ˁ ḫntt	2	*s3wy ḳd*	2
ḫntt ḥrt	3	*ḫ3w*	15 (B2)[47] 20 (B3)
ḫntt ḫrt	3	*ˁrt*	2
ṯms n ḫntt	3	*iwn s3ḥ*	6 (B2) 7 (B3)
spty ḫnwy	4	*rmn ḥry* (B2) *wˁrt ḫrt* (B3)	1
ḥry-ib wi3	4	*[msḏr] s3ḥ*	3 (B2) 1 (B3)
sšmw	4	*rmn ḫry s3ḥ*	1
knmw	2 (B2) 3 (B3)	*ˁ s3ḥ*	3
tpy-ˁ smd	2	*spd*	3
smd	0	*si3t*	3
srt	9	*wˁrt ḫrt s3ḥ + wˁrt ḫrt s3ḥ*	0
Break			

Table 28: Star circles associated with decans in the *Book of Nut*

Table 28 presents the decan list α, which can be fully restored by looking at the versions of

[46] Neugebauer and Parker give 4. B2 has only three, B3 could possibly have four.
[47] Neugebauer and Parker give 20 for both sources.

the vignette from the *Book of Nut* in the Osireion (B2) and in the tomb of Ramesses IV (B3). The number of star circles appearing beneath each decan is also shown (with some amendments to the list given by Neugebauer and Parker). A break occurs between *srt* and *s3wy srt* above Shu's head. The list consists of forty three decans and does not distinguish between ordinary decans and triangle decans.

Seven decans appear in this list that we have not encountered before: *sb3w mḥw*, *ḥry-ib ẖnt*, *iwn s3ḥ*, *msḏr s3ḥ*, *si3t*, *wʿrt ḥrt s3ḥ*, and *wʿrt ẖrt s3ḥ* (which could possibly be identified with *ẖrt wʿrt* which appeared in A1 to A9 and A16). This list does not, therefore, belong to Θ nor Φ, but is a new type of list.

Neugebauer and Parker label the two occurrences of α in B2 and B3 as the only members of a family of decan lists called the 'Seti I A Main Group'. Two subgroups of 'Seti I A' exist, differing from the 'Main Group' in presentation (having deities, planets, and a formal triangle list, all of which are lacking in B2 and B3, and also differing in the number of stars associated with each decan). 'Seti I A Subgroup A' consists of four closely knit XXth dynasty sources plus one later source (Petosiris[48] c.150 BC which is 'influenced by other lists'[49] and in which only seven ordinary decans and a triangle list are preserved). 'Subgroup B' has only one member, the sarcophagus lid of Nekhtnebef[50] (XXXth dynasty to early Ptolemaic). None of the decan lists in either of the subgroups is displayed in the same contextual arrangement as the two lists in the 'Main Group'. The four members of 'Subgroup A' which exhibit great cohesion all occur in the tombs of XXth dynasty pharaohs in the Valley of the Kings. All four occurrences of the decan list are associated with the same layout of

[48] Number 48 in *Egyptian Astronomical Texts* 3 pp. 64-67 including a diagram of the ceiling, which is reported to be lost.
[49] *Egyptian Astronomical Texts* 3 p. 119.
[50] Number 39 in *Egyptian Astronomical Texts* 3 pp. 53-54 and pl. 25.

astronomical ceiling, one that includes Ramesside star clock tables, two types of circumpolar group layout and another decan list, all of which we shall discuss later.[51]

The decan list α differs from the list from the four main ceilings of 'Seti I A Subgroup A' and the list of Nekhtnebef ('Seti I A Subgroup B') in three main points: α separates *wš3ti bk3ti* into two decans *wš3ti* and *bk3ti*, includes two extra decans *wʿrt ḥrt s3ḥ* and *wʿrt ẖrt s3ḥ*, and omits the planets and triangle decans section which usually follow the main list. In addition, Nekhtnebef includes one extra decan *tpy-ʿ b3wy* which occurs in no other member of the 'Seti I A' family. Neugebauer and Parker identify the appearance of the decan *sb3w mḥw* as the unique feature of the 'Seti I A' family.

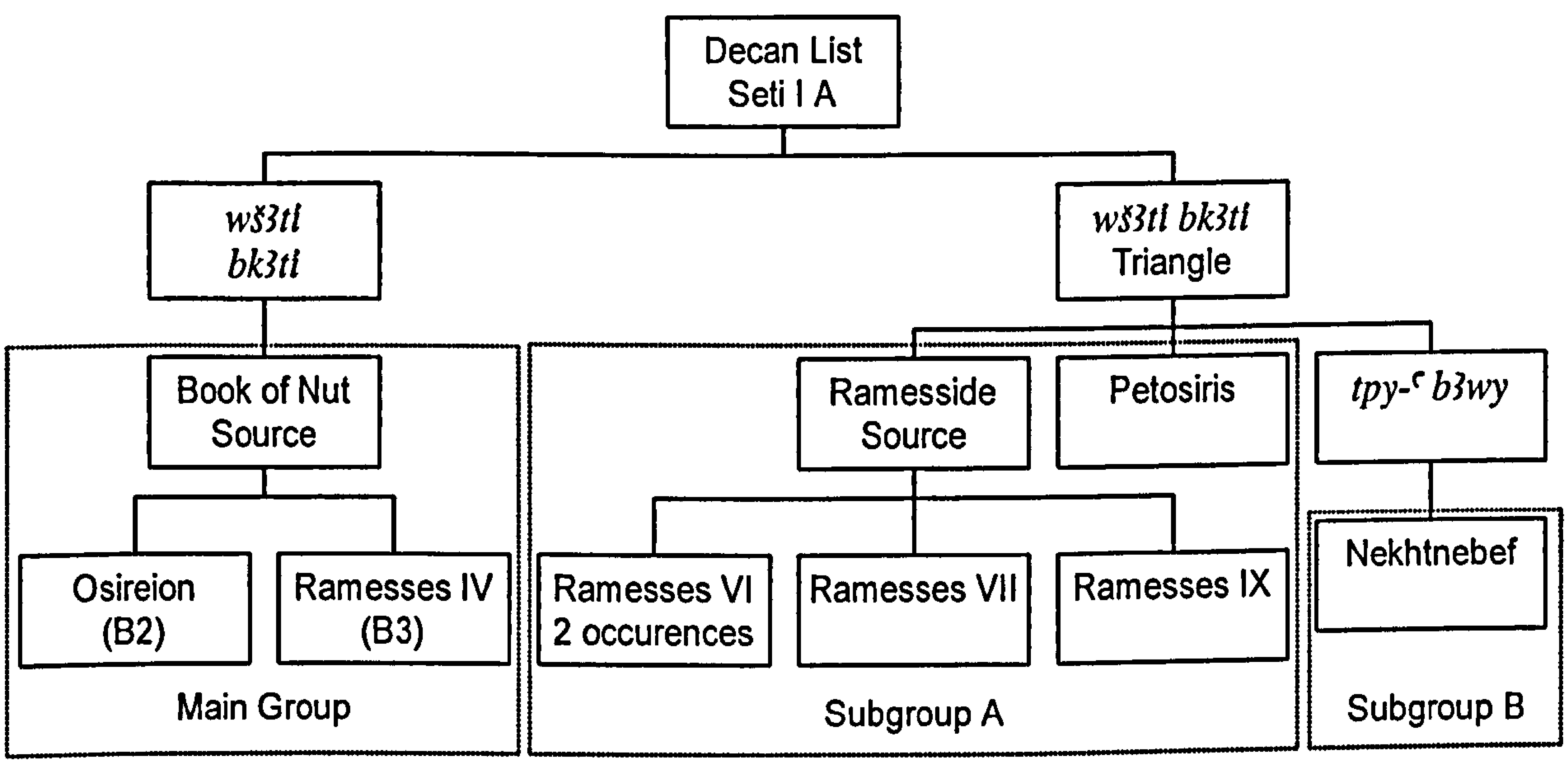


Figure 5: Relationship between sources belonging to the 'Seti I A' family

Figure 5 illustrates the relationships between the members of Neugebauer and Parker's 'Seti I A' family. Considering the probable nature of the sources from which the layouts of the eight members of 'Seti I A' are drawn, there seems to be a problem with tying the eight sources of the family together as strongly as Neugebauer and Parker suggest. The two examples of the *Book of Nut* are obviously from one source. The four astronomical ceilings

[51] See Section H.

from the tombs of three Ramesside kings are based on one other source, which we shall call 'the Ramesside source'.

The *Book of Nut* contains, in summary, the following elements: written information about the motions of the stars and the sun; tabulated data about the motions of the stars with a fragmentary decan list; a description of how to make and use a type of sundial and a diagram of the instrument; a graphical representation of the cosmos with text labels; and a list of forty-three decans.

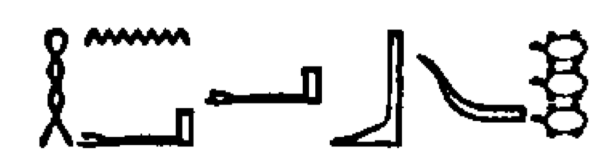
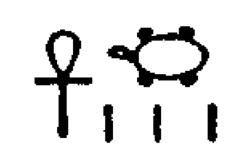
The Ramesside source contains the following elements: two different circumpolar groups; two different decan lists with deities, planets, triangle decans, and pictures of constellations; and twenty-four Ramesside star clock tables.

Apart from some similarities between the decan lists, the Ramesside source therefore bears no resemblance at all to the *Book of Nut* source. Adding the differences between the decan lists to this observation leads us to believe that the 'Seti I A' family, as described by Neugebauer and Parker, cannot realistically be imagined all to have derived directly from a single ancestral decan list. It is far more likely that four separate original sources existed (one for the *Book of Nut*, the 'Ramesside source', and two for the lists of Petosiris and Nekhtnebef) which each happen to contain *sb3w mḥw* and share a few other common features.

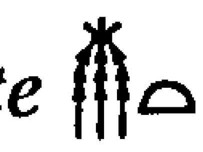
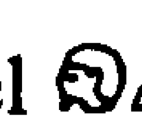
Decan Names Occurring Outside List α

List α is one of two decan lists which appear in sources B2 and B3. The other list is fragmentary and, as we shall see, its composition and function are controversial.

Short text labels are scattered over the Nut vignette. Some of these labels contain decan names which pertain to the list of dates which occur beneath Nut and on her arms. In B2, two decan names appear on the body of Nut under the list α. These two decans are *wʿrt ẖrt* (under *rmn ḥry*) and *sbšsn* (under *ẖry ḫpd n knmt* and *ḥ3t d3t*). In B3, the name *ṯs ʿrḳ* appears under ʿrt. Neugebauer and Parker state that *ṯs ʿrḳ* also occurs in B2, but the joint between ceiling slabs make the name difficult to discern.

In the break between the two halves of the decan list α, there is a label  'The act in the first month of Akhet at the time of the going out of *spdt*[52]'. Near Nut's knees we have   '*Knmt* lives, with *ʿb* and *štw*' or 'Life (of) *knmt*, with *ʿb* and *štw*'. *ʿb* could be an abbreviated form of *ʿbšs*, an alternative writing of *sbšsn*. Two other labels start with 'life':  'life of *štw*' or '*štw* lives' and  'life of *knmt*' or '*knmt* lives'. One further label standing alone in the vignette reads . The first word is unknown, the second is *knmt*.

We have now identified six decan names occurring in labels: *wʿrt ḫrt, ʿb (sbšsn), ṯs ʿrḳ, spdt, knmt,* and *štw*.

A large proportion of the rest of the Nut vignette is taken up with a list of dates. Each entry in this list comprises a set of dates in the form: ' *date*  *date*  *date*'. A few sets are accompanied by decan names. The labels  and  present no reading difficulties, meaning respectively 'Enclosed in the Duat[53]' and 'Birth'. The label , however, is more difficult. Neugebauer and Parker use the translation 'First Hour' although the word 'hour' does not appear in the body of the table. The inclusion of *wnwt* 'hour' only occurs in the text which Neugebauer and Parker label text V which runs horizontally right to left above the sand line under the main body of the table. This text states:

> Of that which is between the star which makes the first hour
> and the star which is enclosed in the Duat:
> there are 9 stars.
> Between the star which is born
> and the star which makes the first hour:
> 20 stars
> giving 29 of those living and working in heaven.

Tp also has the meaning of 'head' which occurs in the *Book of Nut* dramatic text[54] in the

[52] *Prt spdt* – the heliacal rise of Sirius (see Faulkner *Dictionary* p. 91).
[53] The Egyptian 'Netherworld'.
[54] See Part II.

context of meaning the part of the star that is visible to man.

For the moment, we shall use the three words 'First', 'Enclosure', and 'Birth' to denote the actions that occur on the three dates in every set.

The list is cyclical and reads in an anti-clockwise manner. The labels and date sets (here numbered starting at set 1 for the set of dates furthest left along the sand line) are shown in Table 29 in the same order in which they appear in the Nut vignette.

	1	2		3		4		4a	5	
štwy lives	First IIII Akhet 16 Enclosure II Peret 26 Birth I Shemu 6	First IIII Akhet 6 Enclosure III Peret 6 Birth I Shemu 16	*ḫry* *ḫpd* *knmt*	First IIII Akhet 16 Enclosure IIII Peret 16 Birth I Shemu 26	*ḥ3t* *ḏ3t*	First IIII Akhet 26 Enclosure III Peret 16 Birth II Shemu 16	*pḥwy* *ḏ3t*	First Enclosure Birth	First Peret 6 Enclosure Peret 6 Birth Shemu 26	*tm3t* *ḫrt* *ḫrt*
	knmt lives									

Table 29: Date sets and decan names from the *Book of Nut*

Three more date sets (two of them identical) and two decan names occur on the arm of Nut. One date set appears under Nut's breast, directly under the label *sbšsn*. These are shown in Table 30. The label *sḏ* is thought to be a garbled attempt at *ipḏs*.

Under breast	Near shoulder				Near wrist
8	=7		7		6
sbšsn					
First II Peret 6 Enclosure I Shemu 6 Birth III Shemu 16	First ? Peret 26 Enclosure III Peret 26 Birth III Shemu 5	*bk3ti*	First I Peret 26 Enclosure III Peret 26 Birth III Shemu 5	*sḏ*	First ? Peret 26 Enclosure III Peret 16 Birth II Shemu 26

Table 30: Further date sets and decan names from the *Book of Nut*

The rest of the list occurs in columns which fill the areas to the right and the left of the god Shu, under the body of Nut. No decan names occur near these entries. The first entry repeats the set of dates under the breast (see Table 31).

There are thirty-nine entries in the complete list including the entries on the arms and above the sand line. Two are duplicates (=7 and =8) and one (4a) contains no dates. This leaves thirty-six distinct entries.

We can begin to construct a decan list made out of the six decans we collected from labels and the six new decanal labels associated with date sets (*ẖry ḫpd knmt, ḥ3t ḏ3t, pḥwy ḏ3t, ṯm3t ḥrt ẖrt, bk3tl,* and *sḏ*). We can use other decan lists to reconstruct the order in which the decans should appear, and we note that *bk3tl* and *sḏ* (*ipḏs*) are in reverse order on Nut's arm. The order of the fragmentary decan list, which we shall label β, is given in Table 32.

=8	First II Peret 6 Enclosure I Shemu 6 Birth IIII Shemu 16	20	First II Shemu 6 Enclosure ? Akhet 6 Birth III Akhet 16
9	First II Peret 16 Enclosure I Shemu 16 Birth IIII Shemu 26	21	First II Shemu 16 Enclosure I Akhet 15 Birth III Akhet 26
10	First II Peret 26 Enclosure I Shemu 26 Birth IIII Shemu 6	22	First II Shemu 26 Enclosure ? Akhet 6 Birth III Akhet 6
11	First III Peret 6 Enclosure II Shemu 6 Birth IIII Shemu 26	23	First III Shemu 6 Enclosure II Akhet 6 Birth III Akhet 16
12	First III Peret 16 Enclosure II Shemu 16 Birth IIII Peret 26	24	First III Shemu 16 Enclosure II Akhet 16 Birth III Akhet 26
13	First III Peret 26 Enclosure II Shemu 26 Birth I Akhet 26	25	First III Shemu 26 Enclosure II Akhet 26 Birth I Peret 6
14	First IIII Peret 6 Enclosure III Shemu 6 Birth II Akhet 6	26	First IIII Shemu 6 Enclosure III Akhet 6 Birth I Peret 16
15	First IIII Peret 16 Enclosure III Shemu 16 Birth II Akhet 16	27	First IIII Shemu 16 Enclosure III Akhet 16 Birth I Peret 26
16	First IIII Peret 26 Enclosure III Shemu 26 Birth II Akhet 26	28	First III Shemu 26 Enclosure III Akhet 26 Birth II Peret 6
17	First I Shemu 6 Enclosure IIII Shemu 6 Birth II Akhet 6	29	First I Akhet 6 Enclosure IIII Akhet 6 Birth II Peret 16
18	First I Shemu 16 Enclosure IIII Shemu 16 Birth II Akhet 16	30	First I Akhet 15 Enclosure IIII Akhet 16 Birth II Peret 26
19	First I Shemu 26 Enclosure IIII Shemu 26 Birth II Akhet 26	31	First I Akhet 26 Enclosure IIII Akhet 26 Birth III Peret 6
		32	First II Akhet 6 Enclosure I Peret 6 Birth III Peret 16
		33	First II Akhet 16 Enclosure I Peret 16 Birth III Peret 26
		34	First II Akhet 26 Enclosure I Peret 26 Birth IIII Peret 6
		35	First III Akhet 6 Enclosure II Peret 6 Birth IIII Peret 16
		36	First III Akhet 16 Enclosure II Peret 16 Birth IIII Peret 26

Table 31: Date sets without decan names from the *Book of Nut*

We must now turn to the question of which decan applies to which set of dates. Although the sequence of date sets is from left to right along the sand line, the direction of writing of each date set and decan name is right to left throughout the vignette. Along the sand line, decan names could either be written at the head of their date sets (that is, to the right of the dates) or be written at the end of their associated date sets (that is, to the left of the dates). For example, set 3 could belong to either *ḥ3t ḏ3t* or *ẖry ḫpd knmt*. The positioning of *ẖry ḫpd knmt* near to set 2 with Shu's legs between the decan and set 3 makes it clear that the first alternative is the more likely: the name of the decan heads its date set.

β
ṯs ʿrḳ
wʿrt ḥrt
spdt
štwy
knmt
ẖry ḫpd knmt
ḥ3t ḏ3t
pḥwy ḏ3t
ṯm3t ḥrt ẖrt
bk3tl
sḏ
sbššn

Table 32: Fragmentary decan list from the *Book of Nut*

Associating set 2 with *ḥry ḫpd knmt* also fixes the decans *štw* (set 36), *knmt* (set 1), *ḥ3t d3t* (set 3), and *pḥwy d3t* (set 4). We next have the label *tm3t ḥrt ḫrt*, which we have previously encountered in Θ and Φ as two decans, *tm3t ḥrt* and *tm3t ḫrt.*[55] We also have the problem that *bk3ti* appears alone as a label. In every other decan list we have seen, either the single decan *bk3ti* is preceded by the single decan *wš3ti*, or the two appear as one decan *wš3ti bk3ti*. The two problems together give four possible combinations:

Case 1: *tm3t ḥrt ḫrt, wš3ti bk3ti* (two decans)

Case 2: *tm3t ḥrt ḫrt, wš3ti, bk3ti* (three decans)

Case 3: *tm3t ḥrt, tm3t ḫrt, wš3ti bk3ti* (three decans)

Case 4: *tm3t ḥrt, tm3t ḫrt, wš3ti, bk3ti* (four decans)

Neugebauer and Parker favour the first combination and tie this decan list to a group of later lists which they call 'Seti I B'. They ignore the empty date set 4a, which appears at the correct position for *tm3t ḥrt* reinforcing the probability that the name label refers to two decans. The next occurrence of *tm3t ḥrt ḫrt* written[56] as a single decan happens no earlier than about 300 BC.[57] However, the same is true for *ts ʿrḳ* which makes its first appearance in the two New Kingdom sources B2 and B3.

If we look at the possible decan configurations in combination with the position of labels next to date sets, we find the following possible cases, based on cases 1 to 4 above:

Case 1: (*tm3t ḥrt ḫrt, wš3ti bk3ti*) *Sd* (*ipds*) is correctly placed and *bk3ti* is both out of place and badly written. *Sbšsn* is placed near the first occurrence of set 8 and is related to that set.

Case 2: (*tm3t ḥrt ḫrt, wš3ti, bk3ti*) The unlabelled set 6 would apply to *wš3ti*. *Bk3ti* would be

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[55] Note the change in writing from *tm3t* to *tm3t*.
[56] Figure remains in the tomb ceiling of Osorkon II in Tanis (c.832 BC).
[57] According to Neugebauer and Parker's classification in 'families' this decan should appear in source 35 'Tanis' of *Egyptian Astronomical Texts* 3 (pp. 44-48 and pl. 23) which dates from around 600 BC, but is not preserved.

correctly written and placed in front of the second occurrence of its date set 7. *Sḏ* (*ipḏs*) is then out of place as well as being badly written and must be associated with set 8, with *sbšsn* having set 9.

Case 3: (*tmꜣt ḥrt*, *tmꜣt ẖrt*, *wšꜣti bkꜣti*) *Tmꜣt ḥrt* would be associated with set 5 and *tmꜣt ẖrt* with set 6. This leaves the label '*bkꜣti*' (for *wšꜣti bkꜣti*) correctly placed in front of the second occurrence of set 7. *Sḏ* (*ipḏs*) and *sbšsn* must be associated with sets 8 and 9, as happened with case 2.

Case 4: (*tmꜣt ḥrt*, *tmꜣt ẖrt*, *wšꜣti*, *bkꜣti*) Both the writing of *bkꜣti* and the empty date set are both accounted for, but the labels *bkꜣti*, *sḏ* (*ipḏs*) and *sbšsn* are all out of place.

Table 33 illustrates the four cases. Shaded decans indicate that the name appears correctly positioned in association with its date set in the Nut vignette. Note that '*wšꜣti*' does not appear at all in B2 or B3.

Date set	Case 1	Case 2	Case 3	Case 4
1	*knmt*	*knmt*	*knmt*	*knmt*
2	*ḥry ḫpd knmt*	*ḥry ḫpd knmt*	*ḥry ḫpd knmt*	*ḥry ḫpd knmt*
3	*ḥꜣt ḏꜣt*	*ḥꜣt ḏꜣt*	*ḥꜣt ḏꜣt*	*ḥꜣt ḏꜣt*
4	*pḥwy ḏꜣt*	*pḥwy ḏꜣt*	*pḥwy ḏꜣt*	*pḥwy ḏꜣt*
5	*tmꜣt ḥrt ẖrt*	*tmꜣt ḥrt ẖrt*	*tmꜣt ḥrt*	*tmꜣt ḥrt*
6	*wšꜣti bkꜣti*	*wšꜣti*	*tmꜣt ẖrt*	*tmꜣt ẖrt*
7	*sḏ (ipḏs)*	*bkꜣti*	*wšꜣti bkꜣti*	*wšꜣti*
8	*sbšsn*	*sḏ (ipḏs)*	*sḏ (ipḏs)*	*bkꜣti*
9		*sbšsn*	*sbšsn*	*sḏ (ipḏs)*
10				*sbšsn*
...	...	...	...	...
	ṯs ꜥrḳ	*ṯs ꜥrḳ*	*ṯs ꜥrḳ*	*ṯs ꜥrḳ*
	wꜥrt ḥrt	*wꜥrt ḥrt*	*wꜥrt ḥrt*	*wꜥrt ḥrt*
35	*spdt*	*spdt*	*spdt*	*spdt*
36	*štwy*	*štwy*	*štwy*	*štwy*

Table 33: Possible combinations of decan names and date sets in the *Book of Nut*

As we have already noted, the list produced by accepting case 1 conforms to that of a family of lists dating mainly from the Greco-Roman Period called the 'Seti I B' family. The lists formed by the other three cases match no other list exactly, although case 4 differs from A11 only by the omission of a single decan (*sšpt*).

Given the unique nature of the *Book of Nut* source, it is not impossible that the list β should be unique among the known decan lists, in the same way that we found α to be. The recurrence of the decan *ṯs ʿrḳ* in much later lists only indicates that this name was still used for a group of stars and does not prove conclusively that the later decan lists descended directly from the *Book of Nut* source. The same argument applies to the possible fusion of *tmꜣt ḥrt* and *tmꜣt ẖrt* into one decan.

It is definitely not safe, given the arguments above, to state with certainty that the decans missing from β can be supplied from the later members of the 'Seti I B family', as this presupposes that cases 2, 3, and 4 as outlined above have been conclusively eliminated.

It seems that Neugebauer and Parker's argument in favour of case 1 is that a family exists into which the list (in case 1 form) can be inserted, and their dismissal without discussion of cases 2, 3, and 4 is again based on the observation that no obvious 'family' exists into which these possibilities will fit.[58]

This is clearly not an acceptable argument, especially as this list β has a unique role in Egyptian astronomical timekeeping as we shall presently see. Indeed, our discussion of lists α and β suggest strongly that overemphasis on the relationships between decan lists within different layouts is not constructive, and conclusions drawn from associating such decan lists can be shown to be weak once such family ties are questioned.

[58] *Egyptian Astronomical Texts* 1 p. 56 which again mentions *tmꜣt ḥrt ẖrt* as a single decan concerns portions of Papyri Carlsberg 1 and 1a. A decan name written *dm* is used in the phrase 'Opposite *knmt* to *dm* are they, these five stars'. Neugebauer and Parker take 'these five' to be *knmt*, *ẖry ḫpd knmt*, *ḥꜣt ḏꜣt*, *pḥwy ḏꜣt*, and *tmꜣt ḥrt ẖrt*, and that *dm* is *tmꜣt ḥrt ẖrt*, having already decided that this is a single decan. There is no given reason that *dm* cannot refer to *tmꜣt ḥrt* only.

The *Book of Nut* as a Star Clock

We shall now look more closely at the list of dates. One noticeable feature is the regularity of the dates which occur in the table. With the exception of writing errors, only the 6th, 16th, and 26th days of the month are mentioned. There is a period of exactly three months between the dates of 'First' and 'Enclosure', two months and ten days between 'Enclosure' and 'Birth', and six months and twenty days between 'Birth' and 'First'. No account is made of the epagomenal days.

Date set	First	Enclosure	Birth
1	III Akhet 26	II Peret 26	I Shemu 6
2	IIII Akhet 6	III Peret 6	I Shemu 16
3	IIII Akhet 16	III Peret 16	I Shemu 26
4	IIII Akhet 26	III Peret 26	II Shemu 26
5	I Peret 6	IIII Peret 6	II Shemu 16
6	I Peret 16	IIII Peret 16	II Shemu 26
7	I Peret 26	IIII Peret 26	III Shemu 6
8	II Peret 6	I Shemu 6	III Shemu 16
9	II Peret 16	I Shemu 16	III Shemu 26
10	II Peret 26	I Shemu 26	IIII Shemu 6
11	III Peret 6	II Shemu 6	IIII Shemu 16
12	III Peret 16	II Shemu 16	IIII Shemu 26
13	III Peret 26	II Shemu 26	I Akhet 6
14	IIII Peret 6	III Shemu 6	I Akhet 16
15	IIII Peret 16	III Shemu 16	I Akhet 26
16	IIII Peret 26	III Shemu 26	II Akhet 6
17	I Shemu 6	IIII Shemu 6	II Akhet 16
18	I Shemu 16	IIII Shemu 16	II Akhet 26
19	I Shemu 26	IIII Shemu 26	III Akhet 6
20	II Shemu 6	I Akhet 6	III Akhet 16
21	II Shemu 16	I Akhet 16	III Akhet 26
22	II Shemu 26	I Akhet 26	IIII Akhet 6
23	III Shemu 6	II Akhet 6	IIII Akhet 16
24	III Shemu 16	II Akhet 16	IIII Akhet 26
25	III Shemu 26	II Akhet 26	I Peret 6
26	IIII Shemu 6	III Akhet 6	I Peret 16
27	IIII Shemu 16	III Akhet 16	I Peret 26
28	IIII Shemu 26	III Akhet 26	II Peret 6
29	I Akhet 6	IIII Akhet 6	II Peret 16
30	I Akhet 16	IIII Akhet 16	II Peret 26
31	I Akhet 26	IIII Akhet 26	III Peret 6
32	II Akhet 6	I Peret 6	III Peret 16
33	II Akhet 16	I Peret 16	III Peret 26
34	II Akhet 26	I Peret 26	IIII Peret 6
35	III Akhet 6	II Peret 6	IIII Peret 16
36	III Akhet 16	II Peret 16	IIII Peret 26

Table 34: Idealised version of Text U from the *Book of Nut*

The regularity of the list makes it easy to construct an ideal list of date sets by restoring lost signs, correcting writing errors and eliminating duplicate entries. This ideal list is shown in Table 34.

The period of two months and ten days between 'Enclosure' and 'Birth' is clearly the seventy-day period of invisibility which is a characteristic of a decanal star and which is mentioned in the accompanying text as a period of 'purification in the earth'.[59] The reappearance or 'Birth' of the star is the astronomical event called heliacal rise. The 'Enclosure' of the star represents the disappearance of the star at the beginning of the period of invisibility. This leaves the event called 'First' to be determined.

After 'Birth', the star rises each night slightly earlier than the night before, and reaches a higher altitude in the sky before the light of the sun causes the star to become invisible. Eventually, the star will have risen before night fall and will appear after sunset at some altitude. At the date which the text denotes as 'First', Neugebauer and Parker state that the associated star transits the meridian at the end of the first hour of the night.[60] This action, and the assumption that since the table uses the word 'First' which in text V is used for First Hour, the table must be intended to mark the hours of the night, has led to this type of list being called a *transit star clock*[61] and the list β a list of *transit decans*.[62] Furthermore, the other lists which form the family 'Seti I B' are subsequently labelled 'transit decans' as well.

The collection of date sets 1 to 36 together with a complete decan list β would create a type of star clock different in nature from the diagonal star clocks which we have previously studied. The arrangement is different, being presented as a list instead of as a table. The

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[59] See discussion of *Book of Nut* in Section F.

[60] Parker 'Ancient Egyptian Astronomy' p. 56 states that 'Since a star spends 80 in the east before working, it is clear that it [the star] is transiting when it marks an hour'. In fact, as we shall see in Section D, the event is not as 'clear' as Parker implies.

[61] Clagett *Calendars, Clocks, and Astronomy* pp. 56-59.

[62] *Egyptian Astronomical Texts* 1 p. 115.

lack of emphasis on hours in the two date lists (those contained within B2 and B3) is balanced by a greater interest in the yearly cycle of the stars, although the epagomenal days are ignored entirely. The clock would be used by observing the meridian to see which decan is transiting and, by knowing the date, finding the hour using the date list.

The theory of the existence of such a method of timekeeping will be examined in detail in the context of the development of stellar timekeeping in Section D.

Section C: Ramesside Star Clocks

Introduction

A type of timekeeping device consisting of a set of twenty-four *tables* occurs in three tombs of Ramesside kings. The tables are duplicated in one tomb providing us with four sources, C1 to C4. All four examples occur in the same context: as part of astronomical ceilings.

Each table contains a *figure*, a *grid*, and some lines of *text*. The figure is that of a kneeling, bearded man portrayed full face, and is placed beneath or in front of the grid. The grid consists of seven[63] *vertical lines* and fourteen *horizontal lines*. Usually thirteen N14 *stars* are located on the grid, each occupying one of the thirteen spaces between the horizontal lines and positioned on one of the seven vertical lines.

A set of twenty-four tables is known as a *Ramesside star clock*.

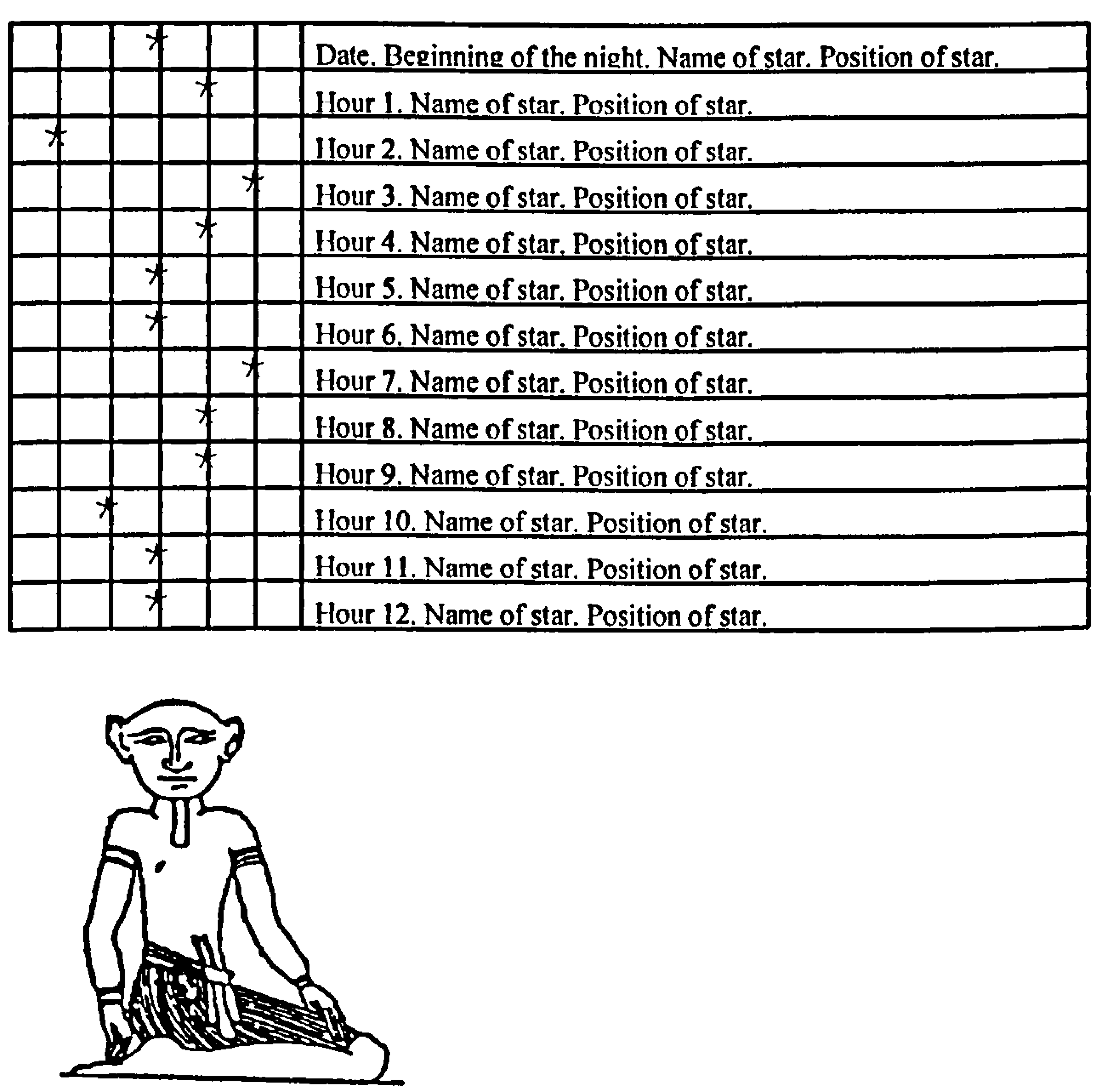

Figure 6: Example of the layout of a Ramesside star clock table

[63] Additional vertical lines may be present, but are not significant to the timekeeping method and as such will be ignored in the following analysis.

The schematic arrangement of one of the tables is given in Figure 6. The date consists of a month name either alone or followed by '[day] 16, the half month'.[64] The first table, which we shall label T1, is dated I Akhet, the second table, T2, has the date I Akhet 16, T3 has II Akhet, T4 has II Akhet 16 and so on until IIII Shemu 16 in T24. No table exists for the epagomenal days.

The hours are written as *tp grḥ*, *wnwt tp*, *wnwt 2-nwt*, *wnwt 3-nwt* ... *wnwt 12-nwt*. We shall refer to these hours in conjunction with the tables by denoting *tp grḥ* (the beginning of the night) as ·0, *wnwt tp* (the first hour) as ·1, *wnwt 2-nwt* (the second hour) as ·2, and so on to *wnwt 12-nwt* as ·12. So the third hour in table 14 would be denoted by T14·3. The position of each star is indicated by the use of one of seven phrases (discussed below).

No other text, either occurring with the tables or from other sources, deals with this type of star clock.

Sources[65]

C1 Ceiling of Tomb of Ramesses VI, KV9
C2 Ceiling of Tomb of Ramesses VI, KV9
C3 Ceiling of Tomb of Ramesses VII, KV7
C4 Ceiling of Tomb of Ramesses IX, KV6

Previous Interpretations of the Tables

Neugebauer and Parker sum up the study of Ramesside star clock tables as follows:

'... Champollion's hypothesis [was] that the stars represent the hours by their risings (so Gensler in 1872). Only in 1874 did Le Page Renouf take the coordinate net seriously, give the proper explanation of the procedure (though he took the tables as a calendar of astronomical observations and not as a star clock) and correctly establish the date for which it was originally designed as about 1450 BC. Le Page Renouf's brilliant paper was apparently overlooked for a long while. Brugsch in his *Thesaurus* (1883) still followed Gensler. In

[64] *Egyptian Astronomical Texts* 2 p. 7.
[65] All are presented in *Egyptian Astronomical Texts* 2.

1891 Bilfinger tried to disprove Renouf's approach and return to the hypothesis of risings in order to obtain a more even distribution in the length of the resulting hours – at the price of declaring both star charts and target figures as meaningless additions to the texts. Finally, Schack-Schackenburg in 1894 rediscovered the significance of the transit lines. Five years later, Borchardt, accepting the interpretation as transits, suggested a specific procedure by means of which the plumb line instrument known as the *mrḫt* could have been used to observe them.'

The accepted interpretation is that the Ramesside star clock is a method for finding the hour of the night by knowing the current half month of the year and observing which star is either exactly on the meridian (represented by the star appearing on the central vertical line), or is just approaching or leaving the meridian (represented by the star occurring on one of the six other vertical lines, three each side of the central line). It can easily be seen from examination of the extant star clock tables that the seven phrases mentioned above each correspond to one of the seven vertical lines on which a star could be placed. The relationship is illustrated below in Figure 7.

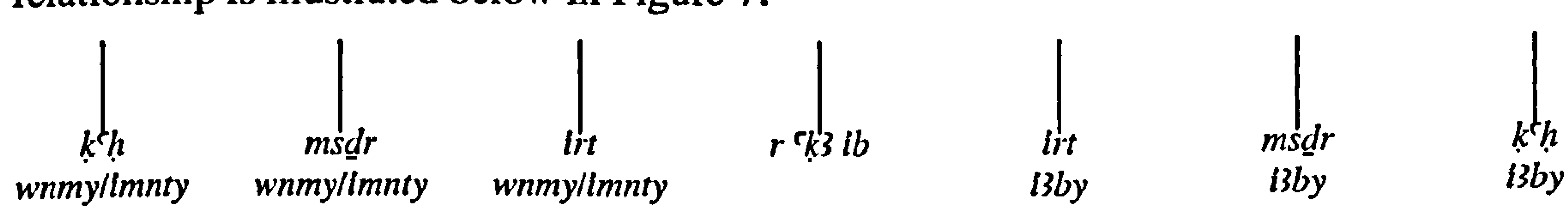

Figure 7: Position labels for the seven central vertical lines from a Ramesside star clock table

The three words *ḳꜥḥ*, *msḏr*, and *ỉrt* are parts of the human body. *Ḳꜥḥ* is the shoulder, elbow or arm, *msḏr* is the ear and *ỉrt* is the eye. *Ỉꜣby* can mean either left-hand (side) or eastern and the two terms *wnmy* and *ỉmnty* both mean right-hand (side). *Ỉmnty* also means western. The writing varies between *wnmy* and *ỉmnty*. The phrase indicating the middle position is *r ꜥḳꜣ ỉb* which means straight forward.[66]

The method employed by the clock is therefore that the stars pursue their east-to-west course across the sky. A star approaches the central line from the east, crosses it, and continues

[66] Faulkner *Dictionary* p. 50.

westwards. The tables give the observer a configuration of star and vertical lines to watch for, and at the moment in time when the star coincides with its predicted position, the hour is fixed. Due to the disparity between the length of the solar day and the sidereal day, the star will cross the central line slightly earlier each night. The division of the year into twenty-four fifteen-day periods, each with a corresponding table, accounts for this retrograde motion. Unlike the decanal stars in the diagonal star clocks discussed previously, the stars used in the Ramesside star clock do not automatically and uniformly shift an hour from table to table.

This is the accepted interpretation of the Ramesside star clock tables. In order to discuss this interpretation, we must note again that we have no further contemporary information about this timekeeping device at all, so all discussion must be based solely on the four sources. The discussion will be centred around three elements of the Ramesside star clock: the seven vertical lines, the significance of the figure, and the list of stars employed.

The Vertical Lines

The middle line *r ꜥḳꜣ ib* has been identified by Le Page Renouf and Schack-Schackenburg as the north-south meridian, but since, as previously mentioned, no further Egyptian literature is available on this subject, the identification must also be considered an assumption rather than a fact.

The nature of the six other vertical lines is open to various interpretations due to the problem of mapping a plane figure onto a spherical model of the night sky. The usual suggestions are that the vertical lines represent one of the three following possibilities:

1) they are lines of equal right ascension
2) they are some kind of physical grid which was held above the seated man
3) they are verticals dropped using a plumb line producing lines of equal azimuth

The first suggestion implies some means of angular measurement, either mechanical or calculated, for which we have no evidence throughout Egyptian science. The second suggestion springs presumably from a literal interpretation of the diagram, and the third is suggested by the existence of a suitable instrument, the surveying instrument called a *mrḫt*.[67] The relevance of a seated target figure is not clear for the second suggestion. Such a system of verticals would be a matter of rigging a frame and strings or thin laths, and would not need a human beneath it. Such a system, if built once, could be left in position for the stars to be consulted at any time. Another possible construction would be to use an opening, such as a doorway, together with threads. The observer would need to stand or sit at one particular point in front of the frame to obtain consistent readings, and the range of stars which could be observed using this system would be increased as the distance between the observer and the verticals decreased. Considering the evidence available, this solution is not completely impossible, but is also not entirely credible.

The third suggestion is perhaps the most likely. The observer would hold the instrument at arm's length so that the string intersected the required part of his partner's body (shown as the seated figure), the right eye, the left ear, etc. Again, the distance between the two men would ideally be the same each time a reading was taken, and they would have to place themselves along the same line. (If the assumption of the central vertical being the meridian is upheld, the observer would always need to be due north of his partner.) The range of stars available depends on the distance between the men and the length of the plumb line, or the observer's capacity to extend mentally the line indicated by the plumb line.

For neither of these two suggestions (frame or plumb line) can the stars used be further north than the zenith, and practically, the stars would be between 10° and 70° in altitude.

[67] This instrument, consisting of a wooden L-shaped handle supporting a plumbline, will be mentioned again in connection with shadow clocks in Section E.

These suggestions arise solely from the grid part of the star clock tables and make varying use of the target figure which is included in each table. However, on first glance at the tables, there is the temptation to think of the grid as positional in both axes, that is, the vertical position of the star symbols having some bearing on the altitude of the star. This is clearly and definitely incorrect: the vertical axis represents time. It may however also be the case that the vertical lines may just be caused by neat presentation (as the horizontal ones contained within the grid certainly are). Both the frame and the plumb line ideas, and to some extent the idea of equal right ascension, spring from a desire to recreate these vertical lines physically for use during observations. This physical interpretation need not be the case. The text supplied with each table provides the information which distinguishes one hour from the next (the vertical separation between stars in the diagram) and also gives the position of each star using one of the seven phrases. The picture shows these two pieces of information using a grid. This grid simply presents this information graphically. The two other pieces of information which are needed to use the clock, that is the date and the names of the stars, only occur in the text. It is therefore entirely possible that the vertical lines in the grid should be intended for exactly the same purpose as the horizontal lines, that of separation and clarification, rather than as an indication of a physical line.

This possibility leaves us with two graphical elements that have meaning, the stars and the figure. The meaning of the star symbol is self evident and unquestioned, but the meaning of the figure has been neglected in the previous literature.

The Figure

A figure appears under each table but does not vary significantly from table to table. The figure is dressed as a priest, with kilt and beard, and is shown kneeling in the typical Egyptian artistic pose showing his legs in profile, his torso in three-quarter profile, and his shoulders frontally. His head is shown full face. This is a departure from the conventions of Egyptian art. The use of full face figures is very unusual. If the figure was meant only for decoration or space filling, he would certainly be shown with his face in profile. That the figure is not included to fill space is clear from his inclusion within the grid itself in source C4 where stars are omitted or displaced around him indicating that the figure was considered to be more important than the grid, and by the way that the other three sources place the figures in an otherwise empty strip below the text and grids. The figure is clearly an important element in the star clock, and its significance must be evaluated.

The kneeling posture is unusual, and must be significant as standing figures are more common and are the default pose where stance is not itself an important element. There is also room for standing figures in the strip in sources C1, C2, and C3, so a kneeling figure was not selected for spatial convenience.

The priestly dress is indicative that this timekeeping method was intended for use by the priesthood and so presumably confines the use of the clock to temple precincts. Such an environment was capable of offering undisturbed observation and the space and materials to construct and maintain whatever equipment was necessary. It also offered a repository for information and a source of men who were literate and disciplined enough to carry out written procedures and to record observations over a period of time. This is probably the environment in which this star clock was developed and also the environment in which this star clock would have been used.

To sum up, the main attributes of the figure are his posture, his face, and his dress. His dress is explained by the temple environment in which the clock would have been used. His posture and his full face we find significant enough to be considered important to the working of the clock.

The Hour Stars

The set of stars whose names occur in the Ramesside star clock tables is usually given the name 'Hour Stars' to distinguish them from the decanal stars. There are forty-seven distinct hour stars. Neugebauer and Parker have divided the stars into thirteen groups labelled E to R (omitting I). They have achieved this by looking at the order of the stars as they travel from hour to hour throughout the tables, and also by considering their names. The complete list is presented in Table 35.

Five groups have just the one member:

F *ꜥryt*, H *sbꜣ n ḫꜣw*, J *sbꜣ n sꜥr*, N *sbꜣ nw mw*, and P *sbꜣ ꜥšꜣw*.

Group E consists of sixteen stars E1-E16 whose names indicate that they belong to the figure of a 'giant' or strong man *nḫt*. He wears two feathers, carries a *ḥḏ* sceptre, and stands on some sort of pedestal. The majority of the star names are anatomical.

Group G has four members which are parts of a bird, the two stars of group K are from or near Orion, similarly group L has two stars related to Sirius. Group O also has a pair of stars from a lion.

Two groups complete the list. Q has six members with names relating to *mnit* (mooring post) and R has eight members named after parts of a female hippopotamus.

Of the thirteen constellations, six are known from other sources. *Ḫꜣw*, *Spdt*, and *Sꜣḥ* regularly appear in decan lists. *Mꜣi*, *Mnit*, and *Rrt* are names which are connected with the circumpolar constellations. These six constellations together contain twenty-one hour stars. It is unlikely that the names *Sꜣḥ* and *Spdt* would be used for more than one constellation each, and previous writers have accepted that K1, K2, L1, and L2 occur in or around Orion and Canis Major. Since *sbꜣ n ḫꜣw* occurs in the list of hour stars in a similar place in relation to *Sꜣḥ* as in the decan lists, this hour star has also been identified as being related to the decan *ḫꜣw*.

E1	*tpy-ꜥ šwty nt nḫt*
E2	*šwty nt nḫt*
E3	*tpy-ꜥ ḥḏ=f*
E4	*tp nḫt*
E5	*tp (n) ḥḏ nt nḫt*
E6	*ḥḏ nt nḫt*
E7	*nḥbt nḫt*
E8	*ḫꜣb=f*
E9	*mndt=f*
E10	*bgs nḫt*
E11	*sḏḥ=f*
E12	*pd nḫt*
E13	*sbḳ=f*
E14	*pt=f*
E15	*iy sꜣ pt=f*
E16	*sbꜣ n sꜣ pt*
F	*ꜥryt*
G1	*bꜥnt nt ꜣpd*
G2	*tp n ꜣpd*
G3	*ḫtyt nt ꜣpd*
G4	*ḳft=f*
H	*sbꜣ n ḫꜣw*
J	*sbꜣ n sꜥr*

K1	*tpy-ꜥ (sbꜣ n) sꜣḥ*
K2	*sbꜣ n sꜣḥ*
L1	*sbꜣ n spdt*
L2	*iy ḥr-sꜣ (sbꜣ n) spdt*
M1	*tpy-ꜥ sbꜣwy*
M2	*sbꜣwy*
N	*sbꜣw nw mw*
O1	*tp n mꜣi*
O2	*sd n mꜣi*
P	*sbꜣw ꜥšꜣw*
Q1	*(tpy-ꜥ) mnit*
Q2	*ṯꜣ nfr*
Q3	*šmsw (n) ḥꜣt (n) mnit*
Q4	*mnit*
Q5	*šmsw n mnit*
Q6	*šmsw iy ḥr-sꜣ mnit*
R1	*rdwy (n) rrt*
R2	*pd n rrt*
R3	*ḥry-ib n mnty=s*
R4	*bꜣḥ n rrt*
R5	*ḫpd n rrt*
R6	*mndt n rrt*
R7	*ns=s*
R8	*šwty n rrt*

Table 35: The Hour Stars from the Ramesside star clock tables, grouped into constellations

The constellations *Mꜣi, Mnit,* and *Rrt* present a problem. The methods of using the star clock tables described above, that is the frame or the plumb line, both rely on the hour stars being situated in the southern half of the visible sky, that is having declination $\delta < \phi$, where ϕ is the latitude of the observer. The region of Canis Major and Orion meets this criterion, but the circumpolar region clearly does not.

To remove the problem, it has been necessary to assume that three other constellations existed named *Mꜣi, Mnit,* and *Rrt* in addition to the three circumpolar ones. The fact that the circumpolar hippo is not labelled as *Rrt* in astronomical ceilings helps this assumption, but the identification of the circumpolar hippo as *Rrt* in the *Book of the Day* does not. That the constellations appear consecutively in the ordered hour star list (Table 35) stretches the bounds of coincidence further. The constellation name *Mnit* means mooring post, a name which has clear implications when used in the circumpolar region, which can be thought of as 'moored' to what we think of as the North Celestial Pole. No southern region has this context in any known text, in other words we have no evidence for a special southern polar region which would have a southern mooring post. The stars are divided into only two groups: the Imperishable Stars (northern circumpolar region) and the Unwearying Stars (the stars which rise and set). There is no obvious connection between the Unwearying Stars and another mooring post. This means that of the three circumpolar-type names, we have no evidence for similarly named southern counterparts and some evidence against such a theory.

A Possible Explanation for the Tables

We have now identified several assumptions associated with the accepted usage of the Ramesside star clock tables:

1) The central vertical line represents the meridian
2) The six other lines represent either a frame with vertical strings or the plumb line of a *mrḫt*
3) Two people aligned North-South were needed to use the clock

Some problems and unexplained areas have also been noted or implied:

1) The figure is kneeling
2) The figure is full face
3) Only one figure is shown[68]
4) There are both decanal constellations and circumpolar constellations in the stars used
5) The physical interpretation of the vertical lines is open to question

This summary implies that the accepted usage does not completely agree with the evidence

[68] Bruins 'Egyptian Astronomy' outlines a theory for a single-observer using his own fist at arm's length to measure units of distance away from an established meridian. His interpretation requires that the grid drawn behind the seated figure be thought of as what the figure (who is now the observer himself) sees in front of him. He gathers support for his theory from the orientation of *ỉ3by* and *wnmy* which now suit 'observer's left' and 'observer's right'. Clagett (*Calendars, Clocks, and Astronomy* p. 146) rejects Bruins' theory disliking in particular the assumption of 'a more highly sophisticated knowledge on the part of Egyptian astronomers ... than seems likely', the lack of reasons for the parts of the body (ear, eye, and shoulder) to be used if this method were employed, and the relationship between the figure and the grid.

presented in the four sources.

If we suppose that the constellations used comprised both circumpolar and decanal stars, and that the portrayal of the figure is vital to the understanding of the Ramesside star clock, a theory presents itself which allows the majority of the problems to be solved, whilst eliminating certain of the assumptions inherent in the accepted usage.

The Reflection Conjecture

The observations of the stars for the construction and use of the Ramesside star clock were made by looking into still water.

This conjecture can be compared with the list of assumptions and problems associated with the previous interpretations of the clock. The first assumption, that the central vertical line represents the meridian, may or may not still stand. Nothing in the reflection conjecture precludes the identification of central vertical with the meridian, but the conjecture also offers another possibility. The conjecture needs the observer to kneel at the edge of a pool. If the edge is straight, the great distance of the stars means that his position along the edge is immaterial, the important factor is the direction in which he is pointing. If he kneels so that his legs are perpendicular to the edge and looks straight into the water, the reflection of his head and shoulders (which would be visible in the starlit Egyptian night) will let him define *r ʿḳ3 ib* using his nose. By leaning forward or backward, or raising himself a little from his haunches he may move his reflection up and down relative to the starry background. *R ʿḳ3 ib* can be defined in this way. If the edge of the pool were East-West, *r ʿḳ3 ib* would be the meridian. It may not be that the accuracy of the alignment in relation to the meridian was very good at all, if the meridian was not the specific goal of this method.

The second assumption, that a frame or plumb line was used to measure the six other positions, now can be discarded. In the same way that *r ʿḳ3 ib* is defined by the observer's reflection, it is clear that the parts of the body named in the six other positional phrases: shoulder, ear, and eye; now form their own references reflected in the water. No strings, laths, grids, frameworks, nor instruments are needed. The observer himself provides the data points.

It can be easily understood that using this method maps the sky, which we describe using spherical co-ordinates, into the positional system described by the star clock tables. The only equipment needed is a pool of water with either a straight edge or one particular position in which to kneel.

The third assumption was that two people were needed to use the tables. This has been completely removed by the reflection conjecture. The lack of a depiction of a second person, perhaps using a *mrḫt*, in the space below each portion of text in sources C1, C2, and C3, cannot be regarded as proof that a second person did not exist, but equally well, the lack of any evidence for a second person except his inclusion in a theory of usage means that his existence is certainly questionable.

Moving on to the problems presented by the previously accepted theories, the posture of the figure is explained very comfortably by the reflection conjecture. It has never been totally clear why the frame or *mrḫt* usage needed the target man to kneel. Indeed, it does not matter for either theory what stance the two observers assume, as long as they are consistent throughout their observations. Kneeling at the edge of water, however, is the most natural way to examine reflections closely.

The reason why the figure is depicted with his features face on is also now very credibly explained. This is the view the observer sees when looking into water: his own face.

The use of both decanal and circumpolar stars is now possible. The circumpolar region for Egypt extends from the horizon to about 60° of altitude. Sirius reached a maximum altitude of around 44°, while the main figure of Orion extended from 43° to 63° at culmination. If we wish to assume that the constellations indicated by the names *Spdt, S3ḥ, M3l, Mnlt,* and *Rrt* retain their usual identifications, the observer would need to be able to view the portion of the sky from around 30° above the northern horizon to 40° above the southern horizon. This corresponds to declinations (epoch 1500 BC) $\delta > -18°$. Does the reflection conjecture allow the entire region to be observed?

Finally, the reflection conjecture allows the vertical lines, including the central one, to be abstract concepts rather than physical entities. The head and shoulders of the observer form references for the positional phrases which can be thought of as lines, but do not require complex procedures to be mapped onto the heavens. The grid represents the information contained within the text, but is not a drawing of the situation. This was previously accepted for the horizontal lines in the grid, and can now be extended to the vertical lines. The position of the star symbols relative to the observer still has meaning.

All the assumptions and problems of the older theories have now been dealt with. The new conjecture itself requires, in addition to the pool, a re-evaluation of the phrases *wnmy/imnty* and *i3by*.

As noted previously, *i3by* means either left-hand (side) or eastern. This phrase is used for stars which occur on the three vertical lines to the *right* of the central line looking at any table (Figure 8). In the conventional interpretation, the centre line is the meridian, and the stars to be viewed are in the southern sky (including the area of Orion and Canis Major). This means that *i3by* cannot refer to the observer's left, or to 'east'. The remaining alternative is that *i3by* refers to the target's left. This leaves either of the readings *wnmy* or *imnty* to mean 'to the target's right' (Figure 9).

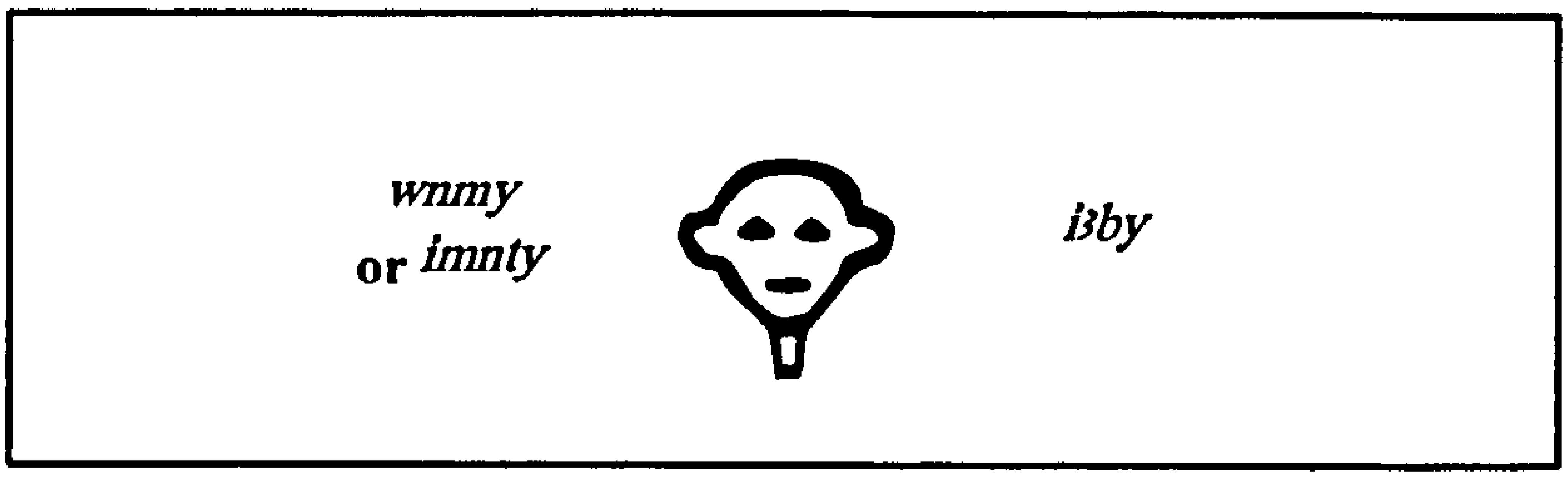

Figure 8: Configuration of Ramesside star clock tables

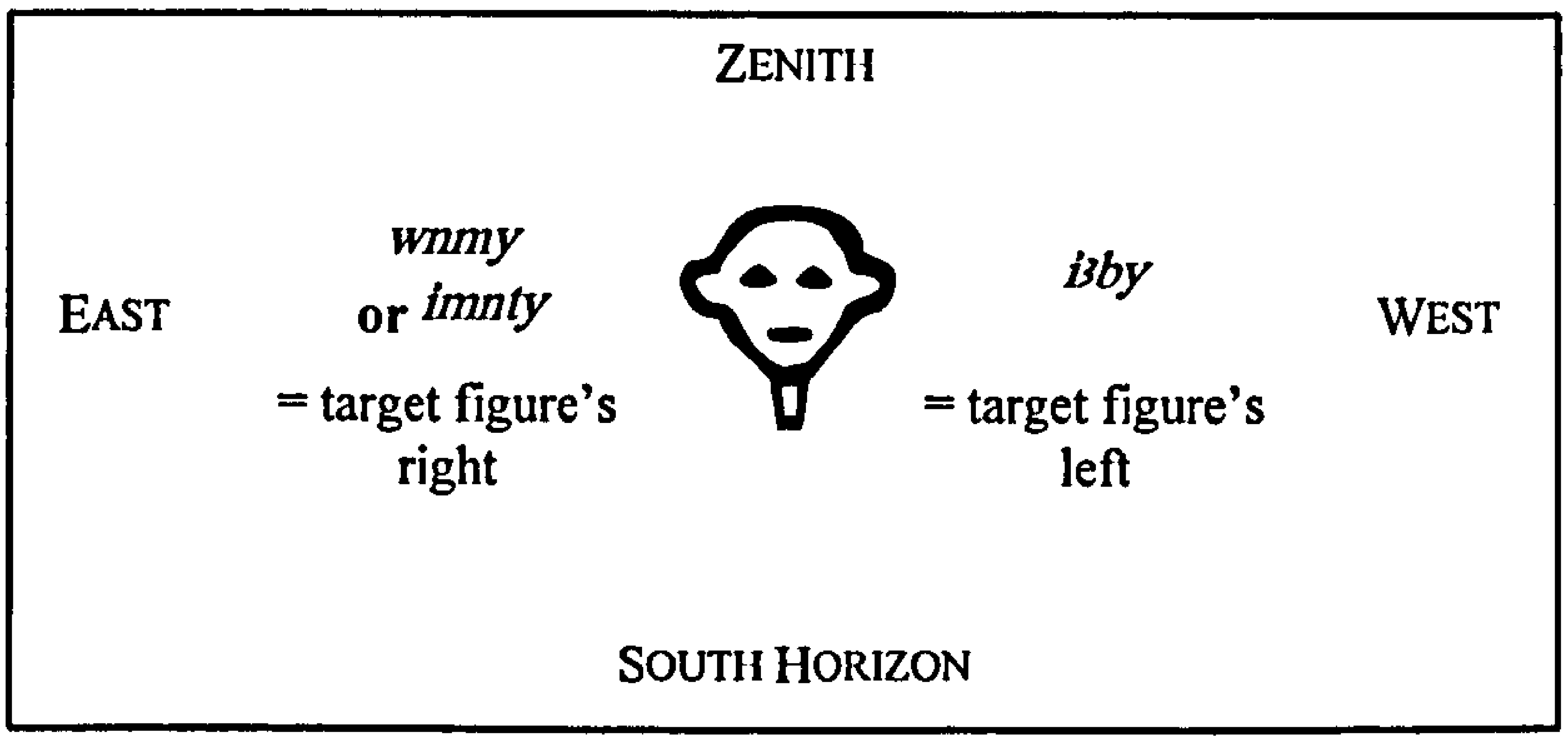

Figure 9: Configuration for conventional interpretation

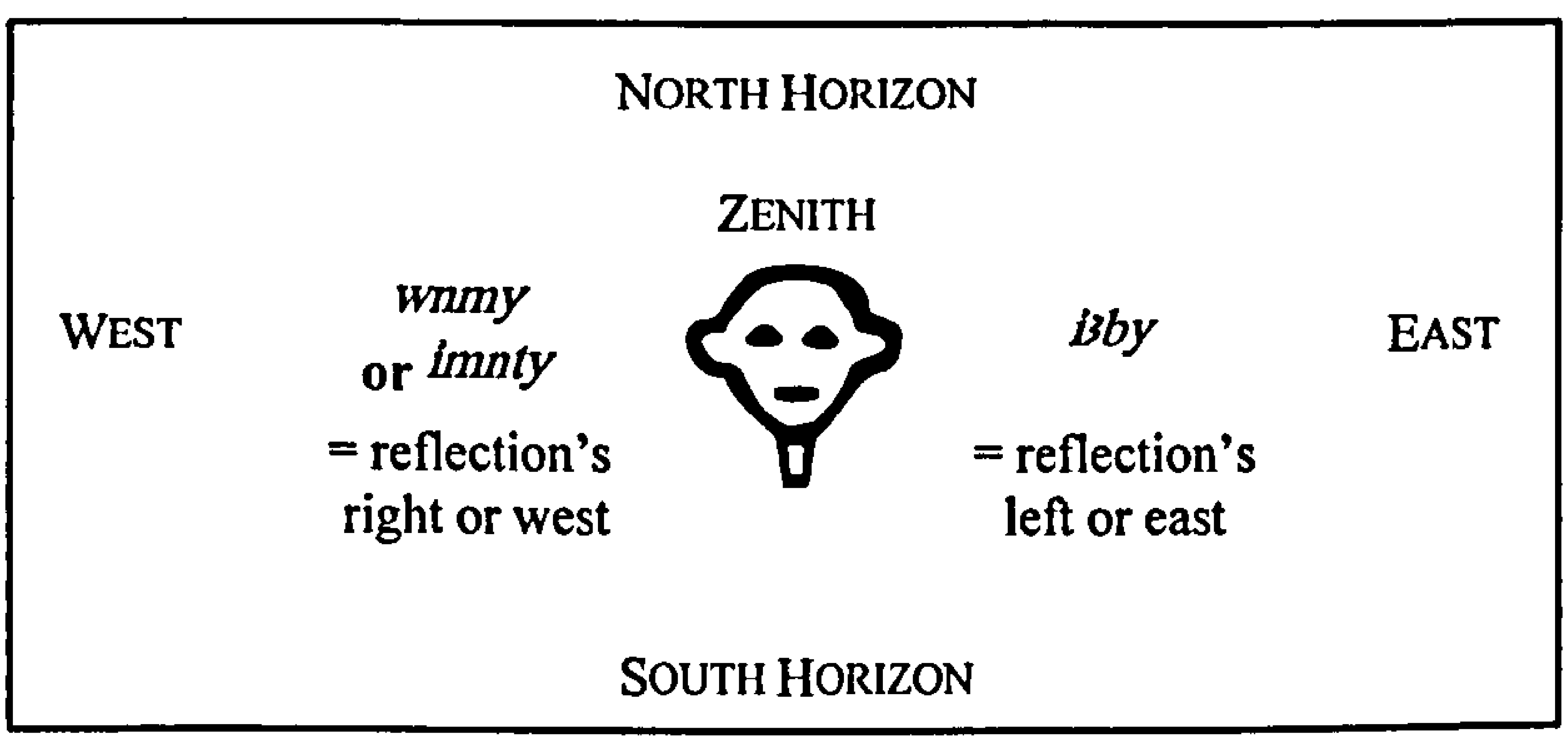

Figure 10: Configuration for reflection conjecture

The reflection conjecture suggests another configuration. If we imagine the observer to sit to the south of the water, either roughly or exactly, we see that the stars near the southern horizon would appear in the water towards the edge, the zenith further out, and the northern horizon further away still. East is to the observer's right. We see that *ỉ3by* could either refer to the reflection's left or, more probably, 'to the east' leaving *ỉmnty* or *wnmy* to indicate either the reflection's left or 'to the west' (Figure 10).

Neugebauer and Parker do not discuss their consistent use of the term *wnmy* rather than *ỉmnty*. In many cases, the word is written using the single sign which can indicate both *wnmy* and *ỉmnty*, the more common usage being *ỉmnty*. The hand determinative D41 which is often used after the *Imnty* or *I3by* sign in the star clock tables does not preclude the east/west meaning of the word.[69] Two readings exist for the words containing the sign 𓋀: western or right-hand. Neugebauer and Parker chose the combination of writing *wnmy* and meaning right-hand, because their interpretation of the tables could not admit the meaning 'western' which is heavily associated with the term *Imnty*.

The role of the target man in the conventional interpretation of the Ramesside star clock is wholly passive, his right and left ears, eyes, and shoulders, were used to describe the positions of stars appearing some way above him. The question of why a man was used in this way has never been properly addressed, due to the lack of further supporting evidence.

From external sources, one other piece of evidence can be offered to support the reflection conjecture. The association between stars and water is very strong in Egyptian literature. The stars were referred to as fish, as birds flying up from the water, and as tears.[70] This implies a link between the two[71] which had been noted as early as the time of the *Pyramid Texts* and makes the idea that stars would be observed in water not as unlikely as would initially seem.

It has already been noted that the Ramesside star clock was probably developed and used only within temple precincts. This means that the sacred lake is an obvious and suitable observing location, providing a reference position for the observer and a still surface[72].

The reflection conjecture, as a new theory for the construction and use of the Ramesside star clock, is an alternative interpretation of the star clock tables. The conjecture appears to fit

[69] Faulkner *Dictionary* p. 8. Also p. 21 and p. 62 give some variants of *Imnty* and *wnmy* writings.

[70] For example in the dramatic dext which will be dealt with in Section F.

[71] For example *Coffin Texts* Spell 62: 'you shall navigate on the Winding Waterway and sail in the eight-boat. These two crews of the Imperishable Stars and the Unwearying Stars shall navigate you, they shall pilot and tow you over the District of the Waters with ropes of iron.' Spell 68: 'the Great Mooring-post speaks to you, a stairway is set up for you from the sea' (Faulkner *Coffin Texts*).

[72] From the use of the tables in the royal tombs at Thebes, Karnak itself may have been the place of origin of the tables. The sacred lake preserved there would provide the ideal observing location.

well with the information provided by the four sources. Unless further evidence is found, the reflection conjecture cannot be proved or disproved, but is presented as an alternative and more sympathetic theory.

Timekeeping Properties of the Ramesside Star Clock

Previous studies have devoted some effort to trying to evaluate the timekeeping properties of the clock. The assumptions made have been that the centre line was the meridian and that a method using two people was employed, constraining the hour stars to those which culminated to the south of the zenith.

The most recent effort has been made by Leitz. He first conjectures that the hours told by the clock were seasonal and uses sunrise and sunset times to evaluate them.[73] He then finds pairs of occurrences of a star at either right ear and left ear, right eye and left eye, or right shoulder and left shoulder. There are sixty-three such pairs in the tables.[74] The time and date of an exact culmination can then be found by finding the time and date midway between the two occurrences. If this culmination occurs on the first or fifteenth day of the month (which happens twenty-four times), this event is sought in the appropriate Ramesside star clock table. In each of the twenty-four cases the star is found at a time reasonably close to that predicted and correctly labelled either *wnmy* or *ỉ3by*.[75]

A similar process is then applied to all 231 occurrences of stars in the position *r ʿḳ3 ỉb*.[76] This produces seventy-nine culminations on the first or fifteenth day of a month. Again, these results are compared with the star clock tables.[77] If his calculated time of transit occurs after the time of transit given by the star clock table and the star is said to be *ỉ3by*, or the

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[73] Leitz *Altaegyptische Sternuhren* tables pp. 137 and 140.
[74] Leitz *Altaegyptische Sternuhren* table pp. 143-145.
[75] Leitz *Altaegyptische Sternuhren* table pp. 145-146.
[76] Leitz *Altaegyptische Sternuhren* table pp. 147-153.
[77] Leitz *Altaegyptische Sternuhren* table pp. 153-156. Occasionally Leitz's data is faulty.

calculated time of transit occurs before the time of transit given by the star clock table and the star is said to be *wnmy*, Leitz marks the occurrence 'yes'. Also, the occurrence is marked 'yes' if the star clock table shows the star as being *r ꜥḳꜣ ỉb*. If none of these three conditions is met, the occurrence is marked 'no'.

Nineteen are found definitely not agreeing with prediction (one falls on IIII Shemu 1, which is the muddled T23) and two more are marked as questionable.

Certain pairs which have a midpoint on a 1st or 15th day are missing from Leitz's table on pp. 153-156. One occurrence (pair 140) appears in the star clock tables, and it seems that Leitz omitted this by mistake. Pair 183 which deals with star M1 produces a midpoint very close to the 6th hour on IIII Akhet 16. In the star clock tables, this position is held by M2. Pairs 75, 76, 129, 167, 189, and 230 occur when the star in question does not appear on the star clock table for the appropriate date and the estimated transit times differ widely from any calculated hour.

Leitz then uses his data to evaluate the position of each hour star in terms of its right ascension, and chooses the most likely star from a shortlist of possible candidates. He then returns to the star clock tables to assess his findings.

Assessment of Leitz's results

The twenty-four results for stars which occur in right/left pairs are shown to be satisfactory.[78] Every star appears in the predicted table and the conditions for *ỉꜣby* and *wnmy* are met. The final column of the results table shows only three question marks. These question marks (pairs 25, 26, and 41) indicate that the star is supposed to be *r ꜥḳꜣ ỉb* at the appropriate time, but actually transit much later (25, 35, and 31 minutes later respectively). However, it seems unreasonable to mark, for example, pair 18 as satisfactory when the star

[78] Leitz *Altaegyptische Sternuhren* table p. 145-146.

should be *ỉrt ỉ3by*, that is just past the meridian, when the discrepancy between actual transit and the required hour is over thirty-seven minutes. In fact, if we allow a generous condition of ±10 minutes for *r ˁḳ3 ỉb*, ±20 minutes for *ỉrt*, and ±30 minutes for *msḏr* and *ḳˁḥ*, we find that only thirteen of the twenty-four results are acceptable. Of course, these limits have been chosen arbitrarily, but are reasonable considering the time scale of on average sixty minutes between one configuration and the next.

Pair	Star	Table	Time of transit (hours)	Seasonal Hour	Time (hours)	Position	Difference between predicted time of transit and seasonal hour (minutes)
4	E10	III Shemu 16	01.26	8	01.19	*r ˁḳ3 ỉb*	-4.2
6	G2	III Akhet 16	20.28	2	20.24	*r ˁḳ3 ỉb*	-2.4
7	G2	III Akhet 1	21.23	3	21.29	*ỉrt ỉ3by*	3.6
8	G4	II Akhet 16	22.82	5	23.08	*r ˁḳ3 ỉb*	15.6
12	J	III Akhet 1	23.83	6	23.85	*r ˁḳ3 ỉb*	1.2
13	J	II Akhet 16	00.59	7	00.72	*ỉrt ỉ3by*	7.8
16	K2	IIII Akhet 16	22.02	4	22.00	*r ˁḳ3 ỉb*	-1.2
17	K2	IIII Akhet 1	23.33	5	22.93	*ỉrt wnmy*	-24
18	K2	III Akhet 16	00.10	7	00.72	*ỉrt ỉ3by*	37.2
25	L2	IIII Akhet 1	00.25	6	23.84	*r ˁḳ3 ỉb*	-24.6
26	M1	I Peret 16	21.80	3	21.21	*r ˁḳ3 ỉb*	-35.4
28	N	IIII Akhet 16	01.30	7	00.85	*ỉrt wnmy*	-27
30	O1	II Peret 1	22.83	4	22.30	*msḏr wnmy*	-31.8
33	O2	III Peret 16	20.77	2	20.73	*r ˁḳ3 ỉb*	-2.4
37	O2	II Peret 1	23.76	5	23.27	*msḏr wnmy*	-29.4
38	O2	I Peret 1	01.93	8	10.95	*r ˁḳ3 ỉb*	1.2
41	P	II Peret 16	23.86	5	23.35	*r ˁḳ3 ỉb*	-30.6
42	P	II Peret 1	01.07	6	00.23	*msḏr wnmy*	-50.4
43	Q3	I Shemu 1	20.58	1	20.14	*ỉrt wnmy*	-26.4
45	Q3	III Peret 1	00.56	6	00.30	*ỉrt wnmy*	-15.6
47	Q3	IIII Peret 16	21.32	3	21.66	*ỉrt ỉ3by*	20.4
50	Q3	III Peret 16	23.40	5	23.37	*r ˁḳ3 ỉb*	-1.8
53	Q4	III Peret 16	00.13	6	00.25	*ḳˁḥ ỉ3by*	7.2
55	R1	IIII Peret 1	00.20	6	00.18	*ỉrt wnmy*	-1.2

Table 36: Leitz's seasonal hour predictions for the Ramesside star clock tables

Table 36 presents a complete list of differences in minutes between the predicted time of transit (using the midpoint method) and the seasonal hours calculated by Leitz.

Looking at the results for stars *r ˁḳ3 ỉb*, of the seventy-nine quoted, only 42% are satisfactory under the condition of seasonal hour time minus actual transit time is ±10 minutes for *r ˁḳ3 ỉb*, ±20 minutes for *ỉrt*, and ±30 minutes for *msḏr* and *ḳˁḥ*. Of the results which must be checked for being before or after the meridian, that is those stars who are given as *ỉ3by* or *wnmy* in the star clock tables, 38% occur on the wrong side of the meridian.

Leitz's method relies on three assumptions: seasonal hours, *r ʿḳ3 ỉb* = the meridian, and the observations being made by two people using a frame or *mrḫt*. He presents an interesting and valuable analysis of the tables, but his results are not conclusive enough to lend weight to any of the three assumptions he uses.

Analysis Issues

The Ramesside star clock tables provide the largest corpus of observational records in the field of Egyptian astronomy. In summary, the clock contains 24 tables x 13 times = 312 data sets concerning the movements of 47 stars. However, the data is somewhat corrupted. The largest area of corruption is T23 which, as Neugebauer and Parker noted,[79] is badly muddled.

Each data set consists of

a) a date
b) a time (beginning of the night, first hour, second hour ... twelfth hour)
c) a star name
d) a position (*ḳʿḥ wnmy*, *msḏr wnmy*, *ỉrt wnmy*, *r ʿḳ3 ỉb*, *ỉrt ỉ3by*, *msḏr ỉ3by*, or *ḳʿḥ ỉ3by*).

Parts a) and b) are sequential and present no problems for reconstructing lost data nor reconciling the four sources. Part c) is often preserved in only one source, but where one or more sources have the name preserved, conflicts sometimes occur. For example, in T1, C4 has the only complete text. The star of T1·5 is *pt=f* and that of T1·6 is *ʿryt*, whereas T1 of C3, which has only one star name preserved, has *ʿryt* in the fifth hour. Neither of the other two sources C1 and C2 contains a readable star name.

[79] *Egyptian Astronomical Texts* 2 p. 65.

I Akhet 1 — T1

	-3	-2	-1	0	1	2	3
0					E2	E2	
1	E5	E5					
2				E7			
3			E10	E10			
4	E11						E11
5					E14	E14	
6				F			
7				G2			
8			G4				
9				H			
10				J			
11				K1			
12	K2						K2

I Akhet 16 — T2

	-3	-2	-1	0	1	2	3
0			E4		E4		
1				E7	E7		
2			E10	E10			
3						E11	E11
4				E14			
5					F	F	
6				G2			
7				G4			
8				H			
9					J		
10				K1			
11				K2			
12	L1						

II Akhet 1 — T3

	-3	-2	-1	0	1	2	3
0				E7	E7		
1				E10	E10	E10	
2				E11	E11		
3				E14	E14		
4				F	F	F	
5					G2	G2	
6				G4			
7				H			
8			J	J			
9			K1				
10			K2				
11					L1		
12				M1			

II Akhet 16 — T4

	-3	-2	-1	0	1	2	3
0				E10			
1				E12			
2				E14			
3					F		
4			G1				
5				G4			
6					H		
7					J		
8				K1	K1		
9							K2
10	L2						
11	M1						M1
12				N			

III Akhet 1 — T5

	-3	-2	-1	0	1	2	3
0				E12			
1				E14			
2					F		
3					G2		
4				G4			
5				H			
6				J			
7				K1			
8			K2				
9					L2		
10				M1			
11				N			
12				O1			

III Akhet 16 — T6

	-3	-2	-1	0	1	2	3
0				E14			
1					F		
2				G2			
3				G4			
4				H			
5			J		J		
6				K1			
7			K2		K2		
8					L2		
9				M1			
10				N			
11				O1			
12				O2			

IIII Akhet 1 — T7

	-3	-2	-1	0	1	2	3
0			E16				
1			G2	G2	G2		
2				G4	G4		
3							H
4							J
5			K2		K2		
6				L2			
7	M1						
8					M2		
9						N	
10							O1
11							O2
12			P		P		

IIII Akhet 16 — T8

	-3	-2	-1	0	1	2	3
0				G2			
1				G4			
2						H	
3						J	
4				K2			
5							L1
6	M2						
7			N		N		
8			O1		O1		
9			O2				
10				P			
11				Q2			
12				Q3	Q3		

I Peret 1 — T9

	-3	-2	-1	0	1	2	3
0				G4			
1			J				
2				K1			
3					K2		
4			L2				
5		M2					
6		N					
7			O1				
8				O2			
9				P	P		
10	Q3		Q3				
11			Q4				
12			Q5				

I Peret 16 — T10

	-3	-2	-1	0	1	2	3
0	K1	K1					
1	K2						
2				L1			
3				M1			
4		M2					
5				N			
6				O1			
7					O2		
8				P			
9	Q3		Q3				
10			Q4				
11	Q5						
12	R2						

II Peret 1 — T11

	-3	-2	-1	0	1	2	3
0	K2						
1						L1	
2		M1				M1	
3			N				
4		O1					
5		O2					
6		P		P			
7				Q2			
8				Q3			
9		Q4		Q4			
10			R1				R1
11			R2				
12				R3			

II Peret 16 — T12

	-3	-2	-1	0	1	2	3
0				L1			
1	L2						L2
2					M2		
3	O1		O1				
4			O2				
5				P			
6				Q2			
7				Q3			
8		Q4					
9				Q5			
10		R2					
11				R3			
12				R5			

Figure 11: Ramesside star clock tables T1 to T12
Grey text indicates that the star appears in that position in some sources, red text indicates that the position given here differs from that given by Neugbauer and Parker

III Peret 1	T13						
	-3	-2	-1	0	1	2	3
0							M1
1			N				
2				O1			
3			O2		O2		
4			P	P			
5			Q2	Q2			
6			Q3	Q3			
7			Q5				
8			R1				
9				R2			
10				R3			
11				R5			
12				R6			

III Peret 16	T14						
	-3	-2	-1	0	1	2	3
0			N	N			
1					O1		
2				Q2			
3				P			
4				Q2			
5				Q3	Q3		Q3
6				Q4			Q4
7					R1		R1
8					R2		
9				R3	R3		
10							R5
11							R6
12				R8			

IIII Peret 1	T15						
	-3	-2	-1	0	1	2	3
0				O1			
1			O2				
2			P		P		
3					Q2		
4			Q3		Q3		
5			Q6		Q6		
6	R1		R1				
7				R2			
8				R3			
9				R5			
10					R6	R6	
11	R7						R7
12						E1	

IIII Peret 16	T16						
	-3	-2	-1	0	1	2	3
0						O2	
1		P	P				
2					Q2		
3					Q3		
4			Q6				
5			R1				
6				R2			
7				R4			
8							R5
9						R6	R6
10							R7
11						E1	
12				E2			

I Shemu 1	T17						
	-3	-2	-1	0	1	2	3
0						Q1	Q1
1			Q3				
2			Q4				
3			Q5				
4				R1			
5				R2			
6						R4	R4
7							R5
8						R6	
9						R8	
10						E1	
11		E2				E2	
12		E5					

I Shemu 16	T18						
	-3	-2	-1	0	1	2	3
0	Q3		Q3				
1					Q4		
2			Q5				
3				R1			
4				R2			
5							R4
6							R5
7	R6	R6				R8	
8						R8	R8
9	E1	E1				E1	
10	E2	E2					
11			E3	E3			
12	E8						E8

II Shemu 1	T19						
	-3	-2	-1	0	1	2	3
0				Q5	•		Q5
1				R1			
2			R2		R2		
3				R4			
4				R5			
5			R6		R6		
6			R7				
7						R8	R8
8		E1				E1	
9				E2			
10				E8			
11				E9			
12				E10			

II Shemu 16	T20						
	-3	-2	-1	0	1	2	3
0				R1			
1				R2			
2				R4			
3				R5			
4					R6		
5					R7		
6						R8	R8
7		E2					
8				E4			
9				E8			
10							E9
11						E10	
12				E12			

III Shemu 1	T21						
	-3	-2	-1	0	1	2	3
0			R4		R4		
1				R5			
2			R6	R6			
3				R7			
4				R8			
5				E1			
6			E2		E2		
7				E7			
8				E9			
9				E10			
10			E12		E12		
11				E13			
12				E14	E14		

III Shemu 16	T22						
	-3	-2	-1	0	1	2	3
0				R5			
1				R6			
2				R7			
3				R8			
4				E1			
5					E2		
6				E8			
7				E9			
8				E10			
9				E12			
10			E13				
11			E15				
12				F			

IIII Shemu 1	T23						
	-3	-2	-1	0	1	2	3
0						R6	
1				E1			
2				E6			
3				E8			
4					E10		
5				E12			
6				E13			
7					E14		
8							F
9							G3
10							G4
11							H
12				K2			

IIII Shemu 16	T24						
	-3	-2	-1	0	1	2	3
0						R8	R8
1				E2			
2				?			
3					E7		
4			E9				
5		E10					
6							E13
7					E14		
8				F			
9						G2	
10					G4		
11		H	H				
12				J			

Figure 12: Ramesside star clock tables T13 to T24
Grey text indicates that the star appears in that position in some sources, red text indicates that the position given here differs from that given by Neugbauer and Parker

In T2, preserved in C1, C3, and C4, all three sources write *sb3 n ꜥryt* instead of *sb3 n sꜥr* in the ninth hour. *Sb3 n sꜥr* agrees with the general order of stars, while *sb3 n ꜥryt* has already been used as T2·5. In the same table in the tenth hour, in C1 and C3, the star name is given as *tpy-ꜥ s3ḥ*, rather than *tpy-ꜥ sb3 n s3ḥ*, while C4 has just *s3ḥ*.

From the examples above and by considering all four sources individually, we can identify six distinct problems with the star name data.

1) The four sources are damaged, sometimes leaving only one source for a star name.
2) A star name could be written incorrectly in one source. In the case cited above, the star *ꜥryt* appears elsewhere in the table, making Neugebauer and Parker state that its appearance in the fifth hour in C3 T1 is a mistake.
3) A star name could be written incorrectly in all the preserved sources. Where the mistake is evident, such as in the case above where *sb3 n ꜥryt* is clearly misplaced and a suitable, similarly spelled candidate is available, such mistakes can be rectified.
4) The similarity of certain star names, coupled with the omission of certain parts of the names can lead to dispute.
5) C4 sometimes compresses two data sets into one line of text.
6) An entire table is sometimes omitted, for example T5 in C3. In the case of T6 in C3, two copies of the text occurred.

These problems arise from three types of scribal error. Firstly, an error in the original source which is reproduced in all four surviving sources. Secondly, an error copying from the original source. Thirdly, confusion caused by layout and graphical considerations.

Before assessing the impact of these problems on the data sets, the fourth piece of information must be discussed: d) the position of the star.

Each table originally consisted of lines of text, a figure, and a grid containing stars. Ideally, the position of the star in the text would agree with the position of the star on the grid. This is not always the case. C3 often places the star symbols between the vertical lines. Some tables have two stars shown for one hour. Comparing sources, it is rare that all four grids agree on the position of a star.

In fact, of the 312 data sets, only six have complete and clear agreement between the grids of all four sources: T4·0 (readable traces in C2), T4·1, T4·2, T21·1 (readable traces in C4), T21·2, and T21·3. T4·4 also agrees if the placing of the star in C3 is taken to be *ỉrt wnmy* rather than being between *ỉrt wnmy* and *msḏr wnmy*. Also, T21·5 is consistent apart from the inclusion of an extra star symbol in C1.

Looking at the texts for these eight data sets, only one text is not preserved (C2 T4·4, texts in C1, C3, and C4 agree with their grids), six sets of texts agree with their grids (T4·0, T4·1, T4·2, T21·1, T21·3, and T21·5) all placing the stars *r ˁḳꜣ ỉb*, and one set (T21·2) C1, C2, and C3 agree with *ỉrt wnmy* but C4 has *r ˁḳꜣ ỉb*.

Of the twenty-four tables, C4 omits T7 through to T18 and T24, leaving only eleven tables. The texts of T6 and T15 each occur twice in C3, and the text of T12 is repeated in C1. Counting each hour of text as one piece of data, and each hour of grid as one piece of data, taking into account the omission and addition of tables detailed above, there is a total of 2262 pieces of data which should have been included in the star clock tables. This figure is reduced by the practice in C4 of placing the figure upon the grid itself, thus losing the positional information for the stars of the later hours, and by various other omissions. These omissions, 219 in number, account for around a 10% loss of pieces of data. Damage to the sources has caused another 25% of data to be lost entirely, while partial damage to lines of text and to stars on grids has occurred to 14% of the data, although the stars can be restored, and some data can be derived from the damaged texts. The remaining 51% of data has survived intact.

Agreement between text and grids is not complete. Comparing each pair of one line of grid and one line of text for each of the four sources (C4 omitting T7 to T18 and T24) gives 1079 pairs of which we have just estimated 65% are preserved well enough to read the position of the star. Of these pairs 72% agree, that is, the position stated in the text and the position of the star on the grid are exactly the same. A further 13% have either more than one star on the grid, with one in agreement with the text, or have the star in a space between two vertical lines but adjacent to the position agreeing with the text. 15% disagree completely.

Looking at the grids for each hour in each table in each source (that is, comparing the grid for T1·0 from each of the four sources, then T1·1 from all four sources, etc.) 112 out of 312 sets of grids (36%) have all the stars in the same position. When these 112 sets of grid data are compared with the relevant texts from all available sources, 83% of texts contain no trace of disagreement with the grids. This figure includes texts which are damaged, but have traces of words which agree with the grid position, and texts from sources which have no grid information preserved, but agree with the grids from other sources. A further 3% of the 112 sets had no accompanying text traces to show agreement or disagreement. The remaining sixteen cases (14% of sets of grid data) were paired with textual data that did not agree. These sixteen cases are detailed below.

1) T12·1. C1 and C3 have text and grid. Both grids and C1 text have *ḳꜥḥ wnmy*. C3 text has *ḳꜥḥ iꜣby*.

2) T15·2. C1 and C3 have text and grid. The C3 text is duplicated. Both grids and C3 text have *irt wnmy*. C1 text has *irt iꜣby*.

3) T15·4. C1 and C3 have text and grid. The C3 text is duplicated. Both grids and C3 text have *irt iꜣby*. C1 text has *irt wnmy*.

4) T15·6. C1 and C3 have text and grid. Both grids and C1 text have *ỉrt wnmy*. C3 text has *ḳꜥḥ wnmy*.

5) T16·12. C1 and C3 have text and grid. Both grids and C3 text have *r ꜥḳꜣ ỉb*. C1 text has *ỉꜣby*.

6) T17·1. C1 and C3 have text and grid. Both grids have *ỉrt ỉꜣby*. Both texts have *ỉrt wnmy*.

7) T18·2. C1 and C3 have text and grid. C2 has a readable grid. All three grids and C1 text have *ỉrt wnmy*. C3 text has *ỉrt ỉꜣby*.

8) T19·2. C1 and C4 have text and grid. C3 has readable text. Both grids and texts from C1 and C3 have *ỉrt wnmy*. C4 text has *ỉrt ỉꜣby*.

9) T19·5. C1 and C4 have text and grid. C3 has readable text. Both grids and texts from C1 and C3 have *ỉrt wnmy*. C4 text has *ỉrt ỉꜣby*.

10) T19·7. C1 has text and grid. C2 has a grid and some readable text. C3 and C4 have text. Both grids have *ḳꜥḥ ỉꜣby*. All texts have *msḏr ỉꜣby*, but there are traces of a possible correction in C2.

11) T19·8. C1 has text and grid. C2 has a grid. C3 and C4 have text. Both grids and text C4 have *msḏr wnmy*. Texts C1 and C3 have *msḏr ỉꜣby*.

12) T21·0. C1 and C3 have text and grid. C2 has readable grid, C4 has some readable text. All three grids have *ỉrt ỉꜣby*. Text C4 has traces of *ỉꜣby*. Texts C1 and C3 have *ỉrt wnmy*.

13) T21·2. All four grids and texts are preserved. All grids, and texts from C1, C2, and C3, have *ỉrt wnmy*. Text from C4 has *r ꜥḳꜣ ỉb*.

14) T21·6. All four grids are readable, as well as texts from C1, C2, and C4. All grids, and texts from C2 and C4 have *ỉrt ỉꜣby*. Text from C1 has *ỉrt wnmy*.

15) T21·10. C1 and C2 have text and grid readable. C4 has a readable grid. All three grids

and text from C2 have *lrt l3by*. C1 text has *lrt wnmy*.

16) T23·0. C3 has text and grid, C1 has a grid. Both grids have *msḏr l3by*. C3 text has *wnmy*.

In constructing their complete star clock tables, Neugebauer and Parker usually take the majority decision as being the one to follow. Of the sixteen discrepancies listed above, 1, 2, 3, 4, 7, 8, 9, 11, 12, 14, 15, and 16 all have the majority of texts and grids pointing at *wnmy*, with one or two disagreeing, stating the star is *l3by*, or vice versa.

In case 5 the majority of texts and grids have *r ʿḳ3 lb*, with only one text stating the star is *l3by*. Similarly, in case 13, the majority of texts and grids have *lrt wnmy*, with only one text stating the star is *r ʿḳ3 lb*.

In these fourteen cases where a clear majority exists, Neugebauer and Parker reject that majority three times: for cases 1, 11, and 15. Each time, the reason for doing so is stated. For case 1 they say 'we accept this [*ḳʿḥ l3by*] in preference to the other extreme position [*ḳʿḥ wnmy*] because this is the only table which has both L1 and L2 in successive hours and not as the virtual alternates they have appeared to be in Tables 2 to 11. They must be stars with transits rather close together and with L1 at 0 [*r ʿḳ3 lb*] it is essential to have the end of the hour of L2 delayed to +3 [*ḳʿḥ l3by*] in order for it to have any appreciable length.' We shall return to this point later.

In case 11, Neugebauer and Parker choose to accept the texts of C1 and C3. They also say that the text of C2 bears out this choice, but the transcript they provide for this text shows the position information as unreadable. The reason for this decision is that 'This [*msḏr l3by*] was the location of E1 in Table 18 and a shift to the left of four positions for no apparent reason would be difficult to accept.'

Finally, in case 15, the reason for ignoring the majority of texts and grids is given as 'it is preferable to accept *wnmy* ... as the correct location since the star skips an hour and was at *ʿḳ3 lb*'

All these three reasons stem ultimately from the model that was chosen by Neugebauer and Parker to explain the construction and use of the Ramesside star clock.

The other two of the sixteen discrepancies, 6 and 10, are not so easy to resolve. For case 6 Neugebauer and Parker follow the text, again to fit in with their model, and similarly for case 10 where all the texts have *msḏr* while both the surviving grids have *ḳꜥḥ*, Neugebauer and Parker again follow the text rather than the grids, although no reasoning is given.

These sixteen cases are the major points of difficulty in reconstructing a complete set of tables, from the point of view of reconciling four sources and the information of texts and grids. Where less information has survived, there is no choice but to accept what is preserved just once as being correct and representative of the lost or omitted portions of other sources. Neugebauer and Parker's Notes for each entry in each table show that extracting data from the sources is a process not easily completed, with constant difficulties in reading and reconciling the information. Neugebauer and Parker have solved some problems by developing a model, and then reading the tables with this model in mind.

When approaching the tables with a new model, as Leitz did, it is necessary to re-read the tables in order to make sure that Neugebauer and Parker's assumptions, based on their own model, do not influence the new work. It is also necessary to admit that although Neugebauer and Parker have produced a complete set of tables, the discrepancies highlighted above indicate that the degree of certainty with which one can say that the data thus gathered represents the original source is not high. It is difficult to quantify the problem, but if (estimating from the agreement of information where several of the sources have been preserved) 14% of data is dubious, about 44 out of 312 data sets in any reconstruction of the tables could be erroneous. Add to this all the problems that may already have been inherent in that original source, and the prospects for mathematical analysis of the data contained within the tables are not good.

To compound these problems with the source material, there is also the problem that analysing these tables by constructing a model and then verifying experimental results against the reconstructed star clock tables involves making several key assumptions. Ideally, a study should solve for one unknown quantity. In the case of the Ramesside star clock, three unknowns are involved: the intended method of using the tables, the length of time periods measured, and the stars used. For example, Leitz wished ultimately to identify stars. To do this he needed to know method of usage and the time periods marked. He had to make assumptions for both, so as he acknowledges, his final results cannot be accepted with certainty, and more importantly, his conjectures about hour length and method of usage are not lent additional support.

Is there any way in which just one of the three unknowns can be isolated and studied?

Impact on the Reflection Conjecture

Having stated that there are three key unknowns to deal with in the analysis of the Ramesside star clock tables, the reflection conjecture aims to satisfy one of them, the problem of method of usage. One certainty about the use of the star clocks is undisputed. That is the motion of the stars. When adjusted for the effects of precession, the stars behave in the same way today as they did whenever the Ramesside star clock was devised.

One important difference between the observational scenario of the reflection conjecture and the conventional, two person method, is linked to the motion of the stars. The stars move from east to west during the course of the night. For the conventional interpretation (Figure 9) this means that the stars move from *wnmy* (the seated figure's right, the observer's left) to *ỉ3by*. For the reflection conjecture the stars, of course, still move from east to west, but because of the different orientation of the observer (Figure 10), this translates into a *ỉ3by* to *wnmy* movement, exactly opposite to that which occurs in the conventional interpretation.

Throughout their work in reconstructing the Ramesside star clock tables, Neugebauer and Parker assume that the stars are moving *wnmy* to *ỉ3by*, which fits in with their model of the situation. Frequently, they choose to follow the written or drawn information which fits with this motion if there is a conflict between sources. For example, we saw earlier how in certain cases where the majority of information pointed towards one interpretation, Neugebauer and Parker instead chose to follow a single occurrence of the opposite location because otherwise the motion of the star in question would not fit with their model.

In particular, they noted (as quoted in case 1, above) that star L2, *sb3 n spdt*, should be at an extreme distance from its usual substitute L1. Due to their interpretation of the tables, this would imply that a *ỉ3by* position was required, hence three consistent pieces of information were discarded, all of which stated that the star was *ḳʿḥ wnmy*, in favour of one piece stating that the star was *ḳʿḥ ỉ3by*. In this case, the reflection conjecture would allow *ḳʿḥ wnmy* to be accepted. The reason this one occurrence is particularly of interest is because of the relationship between the two stars L1 and L2. One or other of these two stars appears in each of the tables T2 to T11, and both appear in T12.

T2	K2	L1	-
T3	K2	L1	M1
T4	K2	L2	M1
T5	K2	L2	M1
T6	K2	L2	M1
T7	K2	L2	M1
T8	K2	L1	M2
T9	K2	L2	M2
T10	K2	L1	M1
T11	K2	L1	M1
T12	L1	L2	M2

Table 37: Occurrences of hour stars L1 and L2

Table 37 summarises their appearances. In each table the L star is preceded by K2, except in T12 where K2 would not be used as it had marked the beginning of the night in T11. Apart from T2, where L1 marks the twelfth hour, the L star is followed by either M1 or M2.

Neugebauer and Parker's reasoning that L1 and L2 transit close together is sound. No other pair of stars in the tables is as strongly linked as L1 and L2, although there are other candidates for alternates, such as E3, E4, E5, and R6 (all occurring not more than twice), Q1 (occurs only once) and Q2, R3 and R4, and Q5 and Q6.

In T12·0, L1 is *r ꜥḳꜣ ib*, although only one grid survives to indicate this. In T12·1 L2 is *ḳꜥḥ wnmy* in three out of four surviving grids and texts. If the two stars transit close together, this indicates that the stars were moving *iꜣby* to *wnmy*.

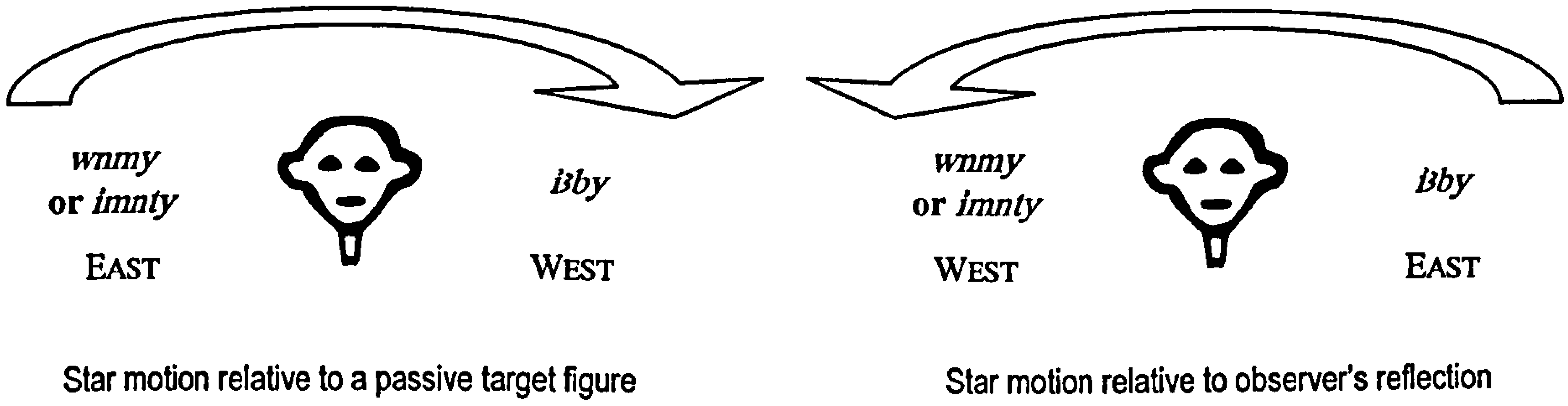


Figure 13: Motion of the stars in relation to the observer for the two theories for the Ramesside star clock

T19·8 and T21·10 have already been mentioned as cases where Neugebauer and Parker ignored the majority of available information in order to fit the motion of the star in question into their model. Other instances of stars not behaving in accordance with Neugebauer and Parker's model occur: T9·9, T9·10 possibly, T11·2, T11·6, T11·10, T14·5, T14·7, T18·7, T18·9, T18·12, and T21·0 possibly.

Creation of a System of Equations for Hour Lengths

The sidereal day is 3 minutes 55.91 seconds shorter than the solar day. This means that a star returns to the same position in the sky 58.977 minutes earlier in the day after fifteen days have elapsed. We shall denote this time period of 58.977 modern minutes by the symbol τ. This time period is the same for any chosen star, at any time of year, for any position in the sky. In other words, no assumptions are being made concerning use of the meridian or choice of star.

If we look at a star that occurs at a single position (for instance *ỉrt wnmy*) on a number of occasions, we can deduce the time that passes between these events, using our own time system as datum. For example, star F is at *ỉrt ỉ3by* in five consecutive tables: T2·5, T3·4, T4·3, T5·2, T6·1. This implies a fifty-nine minute difference between the 'fifth hour' on I Akhet 16 and the 'fourth hour' on II Akhet 1 and so on. E14 is *r ʿḳ3 ỉb* six times: T2·4, T3·3, T4·2, T5·1, T6·0, and T21·12. Fifteen 15-day periods occur between T6 and T21. This means that there is a difference of 15τ or 14 hours and 45 minutes between the 'beginning of the night' in III Akhet 16 and the 'twelfth hour' in III Shemu 1.

Many relationships between hours in different tables can be made this way, building into an incomplete system of equations in τ, with one group of equations for each star. Let us look at star O1 as an example. O1 appears eleven times in the Ramesside star clock tables. It occurs at T5·12 at *r ʿḳ3 ỉb*, T6·11 at *r ʿḳ3 ỉb*, T7·10 at *ḳʿḥ ỉ3by*, T8·8 at *ỉrt wnmy*, T9·7 at *ỉrt wnmy*, T10·6 at *r ʿḳ3 ỉb*, T11·4 at *msḏr wnmy*, T12·3 at *ḳʿḥ wnmy*, T13·2 at *r ʿḳ3 ỉb*, T14·1 at *ỉrt ỉ3by*, and T15·0 at *r ʿḳ3 ỉb*. From T6·11 to T5·12 is τ. From T11·4 to T6·11, 5 x 15 days have passed, so 5τ minutes separate the two occurrences. O1 is at *r ʿḳ3 ỉb* twice more: at T13·2 and T15·0.

We have the following relationships in modern minutes:

T6·11 = T5·12 - τ
T11·4 = T6·11 - 5τ
T13·2 = T11·4 - 2τ
T15·0 = T13·2 - 2τ

If we knew when exactly T5·12 (for example) occurred, we could then fix the other four times.

We can also look at the relationship between hours when the star occurs at different positions. At T7·10, O1 is at *kꜥḥ ꜣby*. The reflection conjecture implies that stars are moving *ꜣby* to *wnmy*. Therefore the star has not yet reached *r ꜥḳꜣ ib*, so the time between T7·10 and T6·11 (when it is *r ꜥḳꜣ ib*) is somewhat more than τ. We cannot quantify the time more accurately because we do not have any certain understanding of what *kꜥḥ ꜣby* means.

At T8·8 O1 appears at *ìrt wnmy*. This in turn implies that the time between T8·8 and T7·10 is quite a lot less than τ, and that the time between T8·8 and T6·11 is 'a bit' less than τ. If we use δ to indicate an indefinite and variable time period taken by a star to go from one position to the next, for example from *ìrt ꜣby* to *r ꜥḳꜣ ib* or from *msḏr wnmy* to *kꜥḥ wnmy*, we can write down relationships in modern minutes between all the appearances of O1. The two we have just discussed are:

$$T7{\cdot}10 = T6{\cdot}11 - \tau - 3\delta$$ [80]

$$T8{\cdot}8 = T7{\cdot}10 - \tau + 4\delta$$

The sign of δ is determined by the motion of the stars which depends on the observational model chosen (*ꜣby* to *wnmy* for the reflection conjecture model would make δ positive in the preceding equations, while the *wnmy* to *ꜣby* motion in the standard interpretation would mean that δ was negative).

We can repeat this process for each star which appears more than once in the star clock tables, forming a system of equations. Neugebauer and Parker have noted that T23 is muddled, so we shall eliminate any references to this table. A correction must also be made to compensate for the extra 5¼ days in the year. The relevant time quantity is denoted by ξ. Of the 47 hour stars, 7 (E3, E6, E15, E16, G1, G3, and Q1) occur only once in the tables, with two of the seven (E6 and G3) occurring only in T23. Our system of equations therefore

[80] From *r ꜥḳꜣ ib* to *kꜥḥ ꜣby* is a move of three positions in the *ꜣby* direction, hence -3δ. Similarly from *kꜥḥ ꜣby* to *ìrt wnmy* is a move of four positions in the *wnmy* direction, hence the term $+4\delta$ in the following equation.

consists of 254 equations and 40 unknowns.[81]

The information that can be gained from these equations is more limited than would at first appear. Although the quantity τ is fixed, we can only speculate about δ. δ is either positive or negative depending on which observation model (conventional or reflection) is used and is a variable quantity because, depending on the declination of the star, a move from one position to the next may entail a greater time difference for one star than a motion through several positions for a different star. However, δ can never be very small because the difference in position of any star in question must be appreciable to the naked eye. Furthermore, the choice of values for the unknowns is critical.

Two approaches were attempted in order to find some information from the equations. In the first approach, the assumption was made that the observations started at some time after sunset, such that the time of the 'beginning of the night' was directly related to the time of sunset. The unknowns were chosen to be the earliest hour at which each star appeared in the tables. The stars of T7·0 and T17·0 were two of the seven stars which occurred only once, but the remaining twenty-one 'beginning of the night' hours accounted for just over half the unknowns (labelled 'a' to 'u').

Results were analysed by setting the unknowns 'a' to 'u' to a set of values which represented a time of first observation at a fixed time after sunset. Following Neugebauer and Parker's analysis, initially T9 marked the longest night, T21 the shortest, and T3 and T15 the equinoxes, but the equations also allowed alteration of the civil date of the longest night.

The system of equations is shown in Table 38. Times not calculable directly from the twenty-one unknowns are shown in grey.

---

[81] There are (13 hours x 23 tables) – 5 stars which occur only once, giving 294 possible quantities, of which 40 are filled by our 'unknowns' leaving 254 equations dependent on the 40 unknowns. δ is an additional unknown and variable time quantity.

	0	1	2	3	4	5	6	7	8	9	10	11	12
T1	a		$c+2\tau+\delta$	$d+3\tau+\delta$		$f+5\tau-1\frac{1}{2}\delta$		$g+7\tau+\delta$	$h+8\tau+2\delta$			$i+9\tau-3\delta$	$j+10\tau-3\delta$
T2	b	$c+\tau-\delta$	$d+2\tau$		$f+4\tau$		$g+6\tau$	$h+7\tau$			$i+8\tau-3\delta$	$j+9\tau-3\delta$	$k+10\tau$
T3	c	$d+\tau-\delta$		$f+3\tau$		$g+5\tau-\delta$	$h+6\tau$			$i+7\tau-2\delta$	$j+8\tau-\delta$	$k+9\tau-\delta$	$l+10\tau+3\delta$
T4	d	$e+\tau$	$f+2\tau$			$h+5\tau$			$i+6\tau-3\delta$	$j+7\tau-6\delta$		$l+9\tau+6\delta$	$m+10\tau$
T5	e	$f+\tau$		$g+3\tau-\delta$	$h+4\tau$			$i+5\tau-3\delta$	$j+6\tau-2\delta$		$l+8\tau+3\delta$	$m+9\tau$	$n+10\tau$
T6	f		$g+2\tau$	$h+3\tau$			$i+4\tau-3\delta$	$j+5\tau-4\delta$		$l+7\tau+3\delta$	$m+8\tau$	$n+9\tau$	$o+10\tau+2\delta$
T7		$g+\tau+\delta$	$h+2\tau-\delta$			$j+4\tau-2\delta$		$l+6\tau+6\delta$		$m+7\tau-2\delta$	$n+8\tau-3\delta$	$o+9\tau-\delta$	
T8	g	$h+\tau$			$j+3\tau-3\delta$	$k+4\tau-3\delta$		$m+6\tau+\delta$	$n+7\tau+\delta$	$o+8\tau+3\delta$			$p+10\tau-2\delta$
T9	h		$i+\tau-3\delta$	$j+2\tau-4\delta$			$m+5\tau+2\delta$	$n+6\tau+\delta$	$o+7\tau+2\delta$		$p+9\tau$		$q+10\tau+2\frac{1}{2}\delta$
T10	i	$j+\tau$	$k+2\tau$	$l+3\tau+3\delta$		$m+4\tau$	$n+5\tau$	$o+6\tau+\delta$		$p+8\tau+2\delta$		$q+9\tau+4\frac{1}{2}\delta$	
T11	j	$k+\tau-2\delta$	$l+2\tau+5\delta$	$m+3\tau+\delta$	$n+4\tau+2\delta$	$o+5\tau+3\delta$			$p+7\tau-\delta$		$r+9\tau-3\delta$		
T12	k			$n+3\tau+3\delta$	$o+4\tau+3\delta$			$p+6\tau-\delta$		$q+7\tau+1\frac{1}{2}\delta$			$t+10\tau$
T13	l	$m+\tau+\delta$	$n+2\tau$	$o+3\tau+2\delta$			$p+5\tau+\frac{1}{2}\delta$	$q+6\tau+2\frac{1}{2}\delta$	$r+7\tau+\delta$			$t+9\tau$	
T14	m	$n+\tau-\delta$	$o+2\tau+2\delta$			$p+4\tau-4\delta$		$r+6\tau-3\delta$			$t+8\tau-3\delta$		$u+10\tau+3\delta$
T15	n	$o+\tau+3\delta$			$p+3\tau-2\delta$		$r+5\tau+\delta$			$t+7\tau$			
T16	o			$p+2\tau-2\delta$		$r+4\tau+\delta$		$s+5\tau+\delta$	$t+6\tau-3\delta$				$a+\xi+9\tau+1\frac{1}{2}\delta$
T17		$p+\tau$		$q+2\tau+2\frac{1}{2}\delta$	$r+3\tau$		$s+4\tau-\delta$	$t+5\tau-3\delta$		$u+7\tau+\delta$		$a+\xi+8\tau+3\frac{1}{2}\delta$	
T18	p		$q+\tau+2\frac{1}{2}\delta$	$r+2\tau$		$s+3\tau-2\delta$	$t+4\tau-3\delta$		$u+6\tau+\delta$		$a+\xi+7\tau+3\frac{1}{2}\delta$		
T19	q	$r+\tau$		$s+2\tau+\delta$	$t+3\tau$			$u+5\tau+\delta$		$a+\xi+6\tau+1\frac{1}{2}\delta$			$d+\xi+9\tau$
T20	r		$s+\tau+\delta$	$t+2\tau$			$u+4\tau+\delta$	$a+\xi+5\tau+3\frac{1}{2}\delta$	$b+\xi+6\tau+\delta$			$d+\xi+8\tau-2\delta$	$e+\xi+9\tau$
T21	s	$t+\tau$			$u+3\tau+3\delta$		$a+\xi+4\tau+\frac{1}{2}\delta$	$c+\xi+6\tau$		$d+\xi+7\tau$	$e+\xi+8\tau-\delta$		$f+\xi+9\tau$
T22	t			$u+2\tau+3\delta$		$a+\xi+3\tau+\frac{1}{2}\delta$			$d+\xi+6\tau$	$e+\xi+7\tau$			
T23													
T24	u	$a+\xi+\tau+1\frac{1}{2}\delta$		$c+\xi+3\tau-\delta$		$d+\xi+4\tau+2\delta$		$f+\xi+6\tau+\delta$		$g+\xi+8\tau-2\delta$	$h+\xi+9\tau-\delta$		

Table 38: System of equations from Ramesside star clock tables based on time of sunset

The only constraint on the results that can be assumed without doubt is that the hours of any one night must follow consecutively. It was found that the choice of the remaining 19 unknowns was critical to fulfilling this criterion. These unknowns had to be supplied by comparison with adjacent times, and hour lengths throughout the tables ranged from a few minutes up to nearly two modern hours.

No further information about the nature of δ could be gathered from this attempt, but it seemed unlikely that starting observations at a time depending on sunset would produce the Ramesside star clocks tables, as the times produced consistently failed to meet the consecutive hours criterion.

The second attempt assumed that the hours of a night were roughly equal. Two nights, T3 and T15, were chosen due to their supposed equinoctial positions, and the time of the beginning of the night in T3 was set to zero, providing a datum. The hour length for T3 and T15 was denoted by λ and μ respectively. Since it cannot be assumed that observation started at the same time in T15 as it did in T3, altering the time of the beginning of the night in T15 was also tried, the offset between the beginning of the night of T3 and the beginning of the night of T15 being labelled ω. Although T3 and T15 would be equinoctial if Neugebauer and Parker's date for the construction of the table is correct, this was not assumed.

All hour points in T3 and T15 could therefore be filled. Only time points directly related to the hours of T3 and T15 were used. The equations are shown in Table 39. Grey cells represent time points that are not directly calculable from T3 and T15.

When these aspects of the table are randomised within realistic limits to generate different combinations, the results can be analysed graphically. A range of values for λ and μ between 30 and 60 minutes, and ω between –120 and 120 minutes fits with known night lengths.

From this method of analysis, two results became apparent:

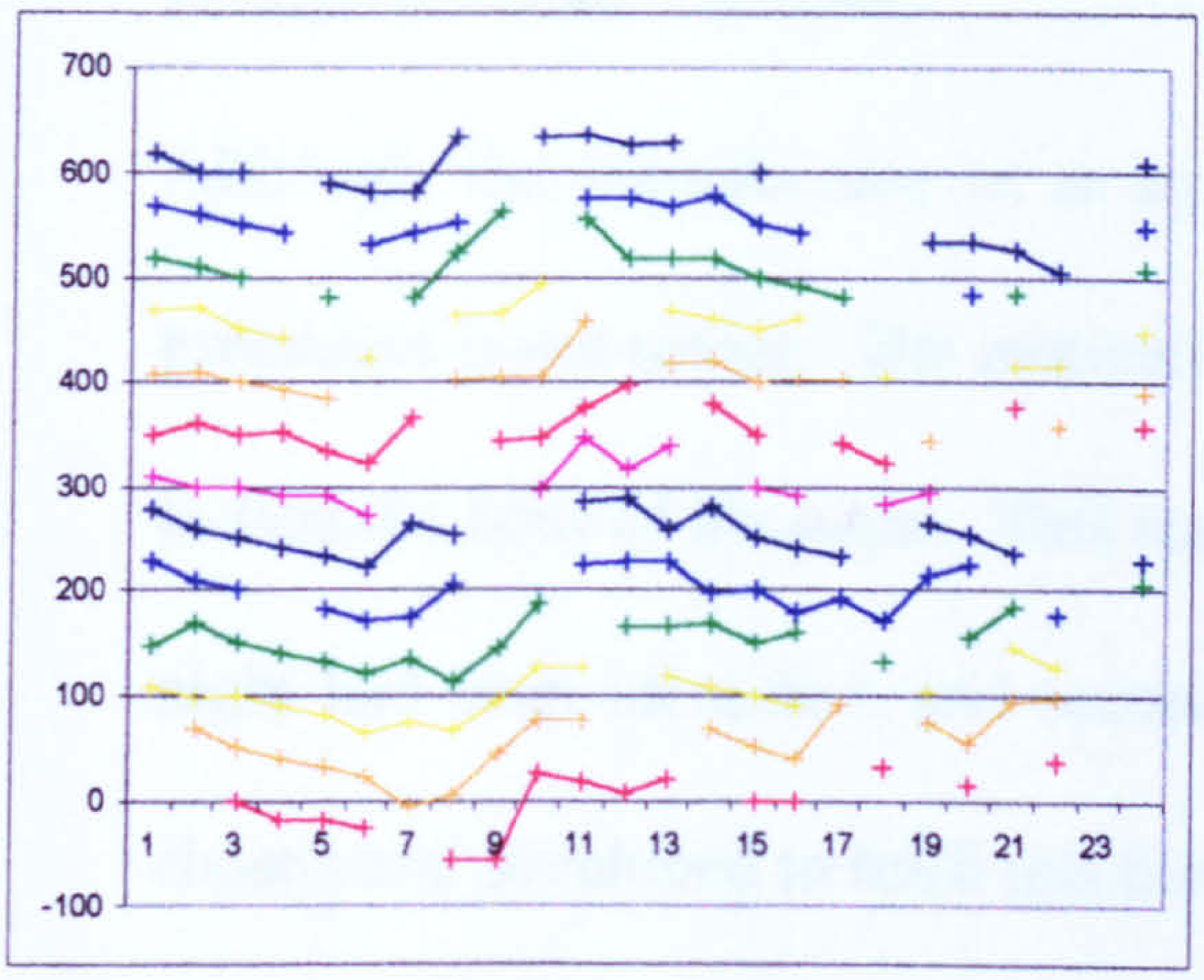
1) There is an inherent discontinuity in time of 'beginning of the night' between T9 and T10. T10·0 always occurs at least 80 minutes and up to 130 minutes later than T9·0. This trend explains why the earlier attempt, based on observations beginning at some time related to sunset, fails to produce consecutive hours under most conditions. (See Figure 14)

2) We can still learn nothing about the nature of δ. With other factors such as constraints on hour length being unresolved, the sign of δ cannot yet be ascertained. This analysis does not, therefore, show that either direction of motion of the stars (that is, for the standard interpretation or for the reflection conjecture) is more likely than the other.

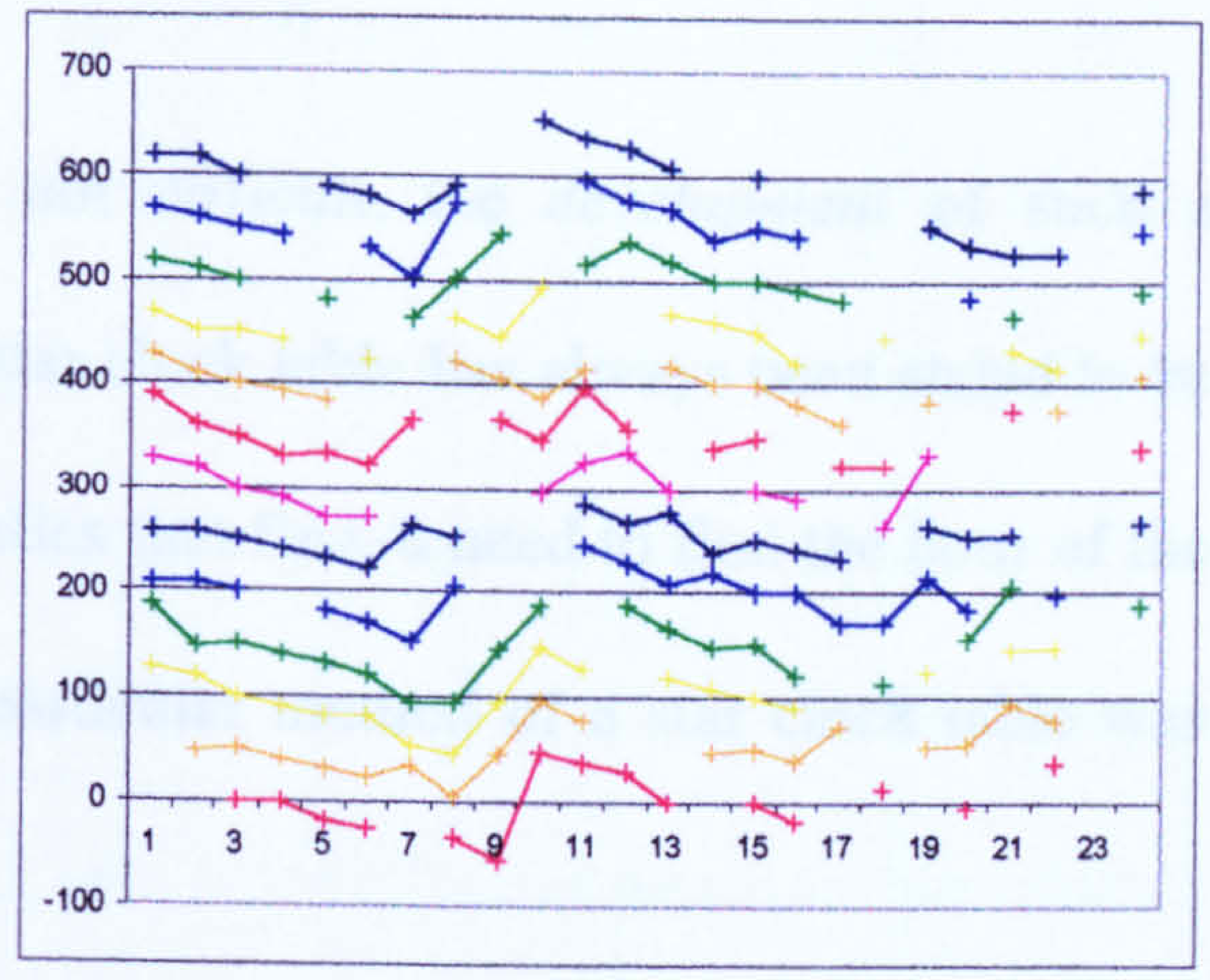
Further analysis of the Ramesside star clock tables might be capable of revealing more information concerning the nature of the night hours, and may resolve the question of how the tables were originally constructed. The motive for their construction and their place in Egyptian timekeeping history will be discussed in the next section.

	0	1	2	3	4	5	6	7	8	9	10	11	12
T1			$2\tau+\delta$	$\lambda+2\tau+2\delta$	$2\lambda+2\tau-2\delta$	$3\lambda+2\tau-1\frac{1}{2}\delta$	$4\lambda+2\tau+2\delta$	$5\lambda+2\tau+2\delta$	$6\lambda+2\tau+2\delta$	$7\lambda+2\tau+\delta$	$8\lambda+2\tau$	$9\lambda+2\tau-\delta$	$10\lambda+2\tau-2\delta$
T2		$\tau-\delta$	$\lambda+\tau+\delta$	$2\lambda+\tau-3\delta$	$3\lambda+\tau$	$4\lambda+\tau$	$5\lambda+\tau+\delta$	$6\lambda+\tau$	$7\lambda+\tau$	$8\lambda+\tau-2\delta$	$9\lambda+\tau-\delta$	$10\lambda+\tau-2\delta$	$11\lambda+\tau+\delta$
T3	0	λ	2λ	3λ	4λ	5λ	6λ	7λ	8λ	9λ	10λ	11λ	12λ
T4	$\lambda-\tau+\delta$	$2\lambda-\tau$	$3\lambda-\tau$	$4\lambda-\tau$		$6\lambda-\tau$	$7\lambda-\tau-\delta$	$8\lambda-\tau-2\delta$	$9\lambda-\tau-\delta$	$10\lambda-\tau-5\delta$		$12\lambda-\tau+3\delta$	
T5	$2\lambda-2\tau$	$3\lambda-2\tau$	$4\lambda-2\tau$	$5\lambda-2\tau$	$6\lambda-2\tau$	$7\lambda-2\tau$	$8\lambda-2\tau-\delta$	$9\lambda-2\tau-\delta$	$10\lambda-2\tau-\delta$		$12\lambda-2\tau$		$\omega+10\tau$
T6	$3\lambda-3\tau$	$4\lambda-3\tau$	$5\lambda-3\tau+\delta$	$6\lambda-3\tau$	$7\lambda-3\tau$	$8\lambda-3\tau$	$9\lambda-3\tau-\delta$	$10\lambda-3\tau-3\delta$		$12\lambda-3\tau$		$\omega+9\tau$	$\omega+\mu+9\tau-\delta$
T7		$5\lambda-4\tau+2\delta$	$6\lambda-4\tau-\delta$	$7\lambda-4\tau-3\delta$	$8\lambda-4\tau-4\delta$	$10\lambda-4\tau-\delta$		$12\lambda-4\tau+3\delta$			$\omega+8\tau-3\delta$	$\omega+\mu+8\tau-4\delta$	$\omega+2\mu+8\tau-2\delta$
T8	$5\lambda-5\tau+\delta$	$6\lambda-5\tau$	$7\lambda-5\tau-2\delta$	$8\lambda-5\tau-3\delta$	$10\lambda-5\tau-2\delta$	$11\lambda-5\tau-2\delta$			$\omega+7\tau+\delta$	$\omega+\mu+7\tau$	$\omega+2\mu+7\tau-\delta$	$\omega+3\mu+7\tau+\delta$	$\omega+4\mu+7\tau-4\delta$
T9	$6\lambda-6\tau$	$8\lambda-6\tau$	$9\lambda-6\tau-\delta$	$10\lambda-6\tau-3\delta$				$\omega+6\tau+\delta$	$\omega+\mu+6\tau-\delta$	$\omega+2\mu+6\tau-\delta$	$\omega+4\mu+6\tau-2\delta$		
T10	$9\lambda-7\tau+2\delta$	$10\lambda-7\tau+\delta$	$11\lambda-7\tau+\delta$	$12\lambda-7\tau$			$\omega+5\tau$	$\omega+\mu+5\tau-2\delta$	$\omega+2\mu+5\tau-\delta$	$\omega+4\mu+5\tau$			$\omega+7\mu+5\tau+\delta$
T11	$10\lambda-8\tau+\delta$	$11\lambda-8\tau-\delta$	$12\lambda-8\tau+2\delta$		$\omega+4\tau+2\delta$	$\omega+\mu+4\tau+\delta$	$\omega+2\mu+4\tau-\delta$	$\omega+3\mu+4\tau+5\delta$	$\omega+4\mu+4\tau-3\delta$		$\omega+6\mu+4\tau-4\delta$	$\omega+7\mu+4\tau+\delta$	$\omega+8\mu+4\tau$
T12	$11\lambda-9\tau+\delta$			$\omega+3\tau+3\delta$	$\omega+\mu+3\tau$	$\omega+2\mu+3\tau-\delta$	$\omega+3\mu+3\tau+\delta$	$\omega+4\mu+3\tau-3\delta$			$\omega+7\mu+3\tau+2\delta$	$\omega+8\mu+3\tau$	$\omega+9\mu+3\tau$
T13	$12\lambda-10\tau-3\delta$		$\omega+2\tau$	$\omega+\mu+2\tau-\delta$	$\omega+2\mu+2\tau-\frac{1}{2}\delta$	$\omega+3\mu+2\tau+1\frac{1}{2}\delta$	$\omega+4\mu+2\tau-2\frac{1}{2}\delta$		$\omega+6\mu+2\tau$	$\omega+7\mu+2\tau$	$\omega+8\mu+2\tau$	$\omega+9\mu+2\tau$	$\omega+10\mu+2\tau-2\delta$
T14		$\omega+\tau-\delta$	$\omega+\mu+\tau-\delta$	$\omega+2\mu+\tau-\delta$	$\omega+3\mu+\tau+\delta$	$\omega+4\mu+\tau-6\delta$		$\omega+6\mu+\tau-4\delta$	$\omega+7\mu+\tau-\delta$	$\omega+8\mu+\tau$	$\omega+9\mu+\tau-3\delta$	$\omega+10\mu+\tau-5\delta$	
T15	ω	$\omega+\mu$	$\omega+2\mu$	$\omega+3\mu$	$\omega+4\mu$	$\omega+5\mu$	$\omega+6\mu$	$\omega+7\mu$	$\omega+8\mu$	$\omega+9\mu$	$\omega+10\mu$	$\omega+11\mu$	$\omega+12\mu$
T16	$\omega+\mu-\tau-3\delta$	$\omega+2\mu-\tau$	$\omega+3\mu-\tau$	$\omega+4\mu-\tau-4\delta$	$\omega+5\mu-\tau+\delta$	$\omega+6\mu-\tau$	$\omega+7\mu-\tau$		$\omega+9\mu-\tau-3\delta$	$\omega+10\mu-\tau-4\delta$	$\omega+11\mu-\tau$	$\omega+12\mu-\tau$	
T17		$\omega+4\mu-2\tau-2\delta$			$\omega+6\mu-2\tau-\delta$	$\omega+7\mu-2\tau$		$\omega+9\mu-2\tau-3\delta$	$\omega+10\mu-2\tau$		$\omega+12\mu-2\tau$		
T18	$\omega+4\mu-3\tau-2\delta$			$\omega+6\mu-3\tau-\delta$	$\omega+7\mu-3\tau$		$\omega+9\mu-3\tau-3\delta$	$\omega+10\mu-3\tau$		$\omega+12\mu-3\tau+4\delta$			
T19		$\omega+6\mu-4\tau-\delta$	$\omega+7\mu-4\tau+\delta$		$\omega+9\mu-4\tau$	$\omega+10\mu-4\tau-\delta$	$\omega+11\mu-4\tau+4\delta$		$\omega+12\mu-4\tau+4\delta$				$\lambda+\xi+8\tau+\delta$
T20	$\omega+6\mu-5\tau-\delta$	$\omega+7\mu-5\tau$		$\omega+9\mu-5\tau$	$\omega+10\mu-5\tau-3\delta$	$\omega+11\mu-5\tau+2\delta$						$\lambda+\xi+7\tau+\delta$	$2\lambda+\xi+7\tau$
T21		$\omega+9\mu-6\tau$	$\omega+10\mu-6\tau-\delta$	$\omega+11\mu-6\tau+3\delta$		$\omega+12\mu-6\tau+2\delta$		$\xi+6\tau$		$\lambda+\xi+6\tau+\delta$	$2\lambda+\xi+6\tau-\delta$		$3\lambda+\xi+6\tau$
T22	$\omega+9\mu-7\tau$	$\omega+10\mu-7\tau-2\delta$	$\omega+11\mu-7\tau+3\delta$		$\omega+12\mu-7\tau+2\delta$				$\lambda+\xi+5\tau+\delta$	$2\lambda+\xi+5\tau$			$4\lambda+\xi+5\tau+\delta$
T23													
T24				$\xi+3\tau-\delta$		$\lambda+\xi+3\tau+3\delta$		$3\lambda+\xi+3\tau\delta$	$4\lambda+\xi+3\tau+\delta$	$5\lambda+\xi+3\tau-\delta$	$6\lambda+\xi+3\tau-\delta$	$7\lambda+\xi+3\tau+2\delta$	$8\lambda+\xi+3\tau-\delta$

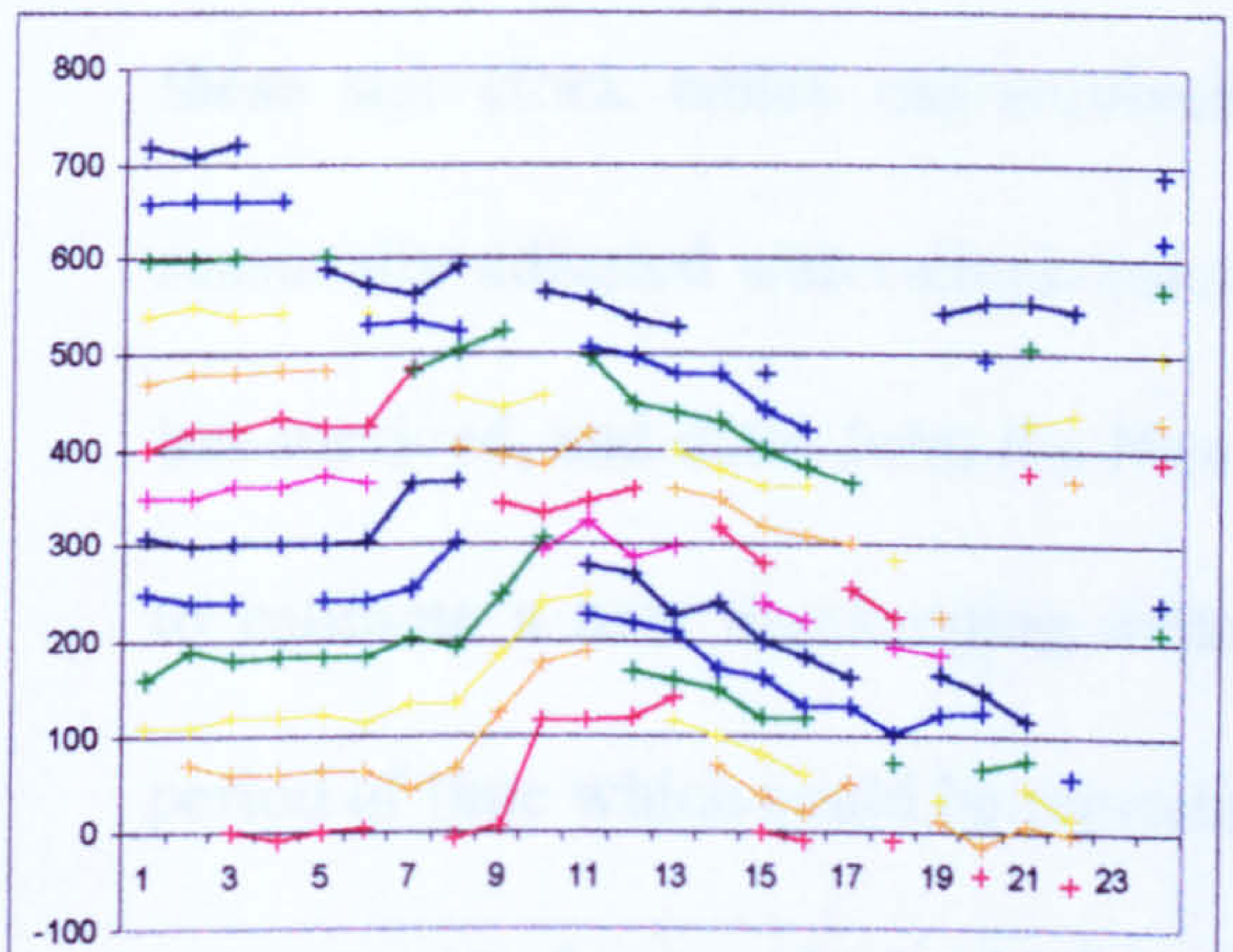
Table 39: System of equations from Ramesside star clock tables based on equal hours during one night



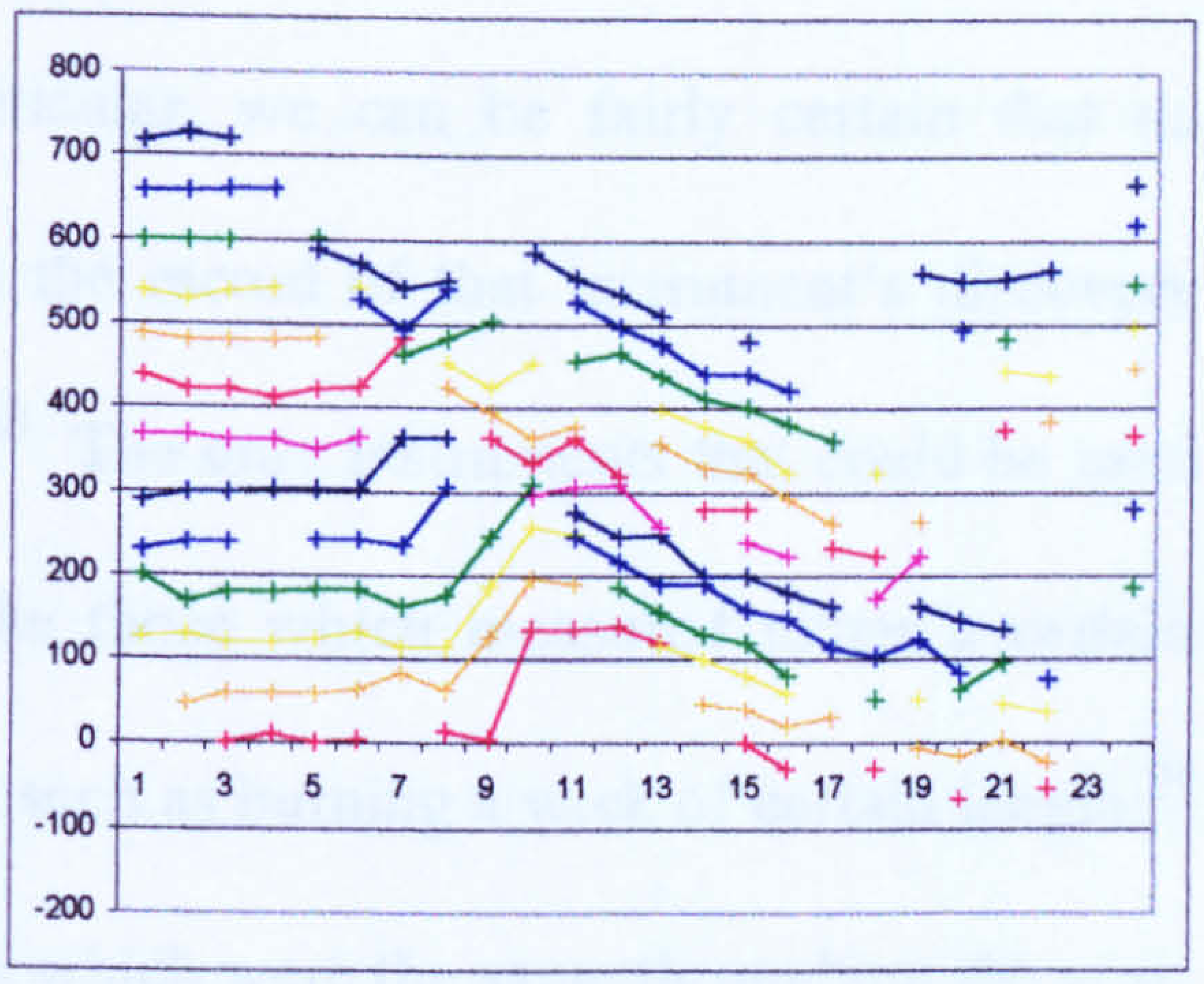
$\lambda = 50\ \mu = 50\ \omega = 0\ \delta = -10$



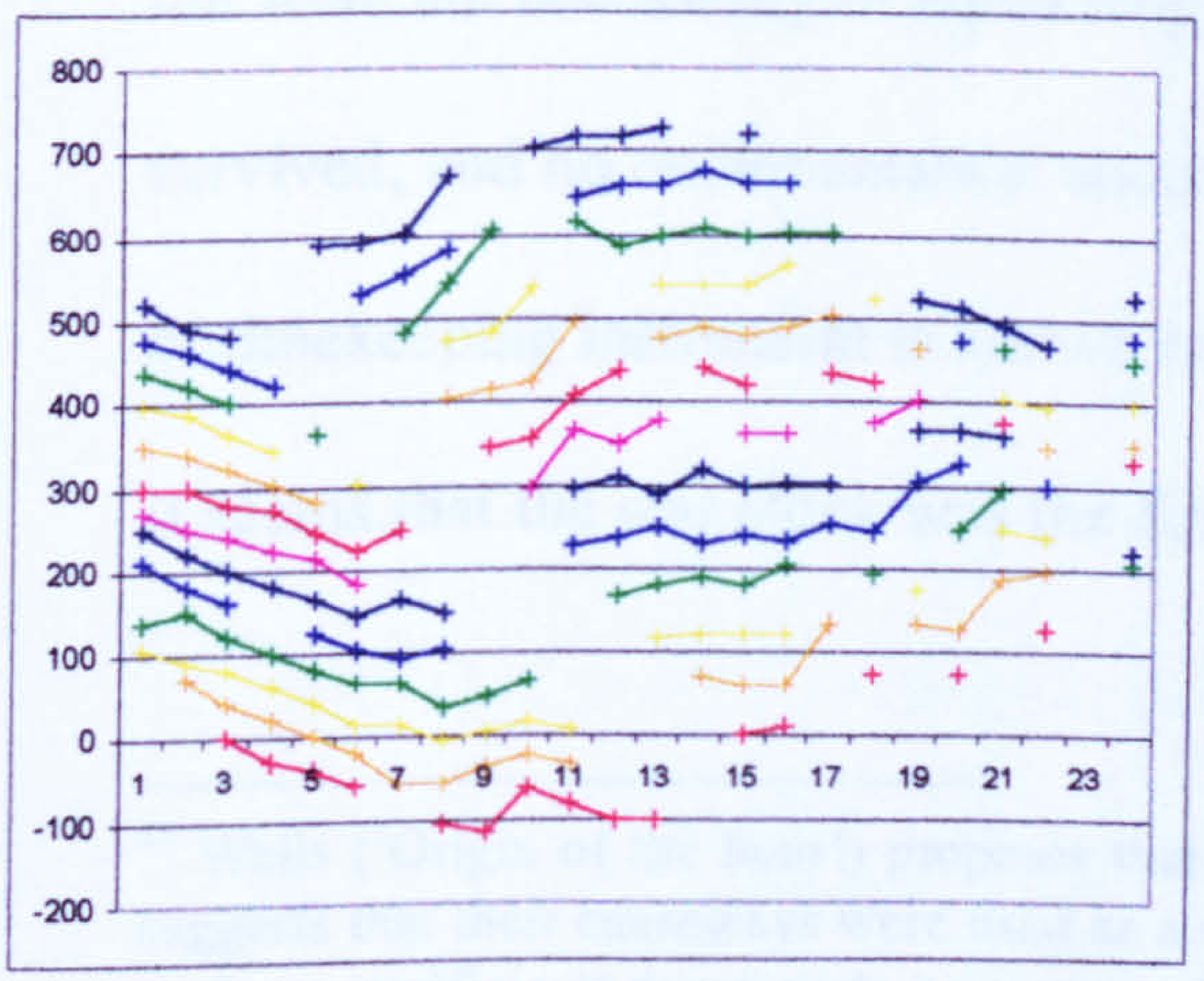
$\lambda = 50\ \mu = 50\ \omega = 0\ \delta = 10$



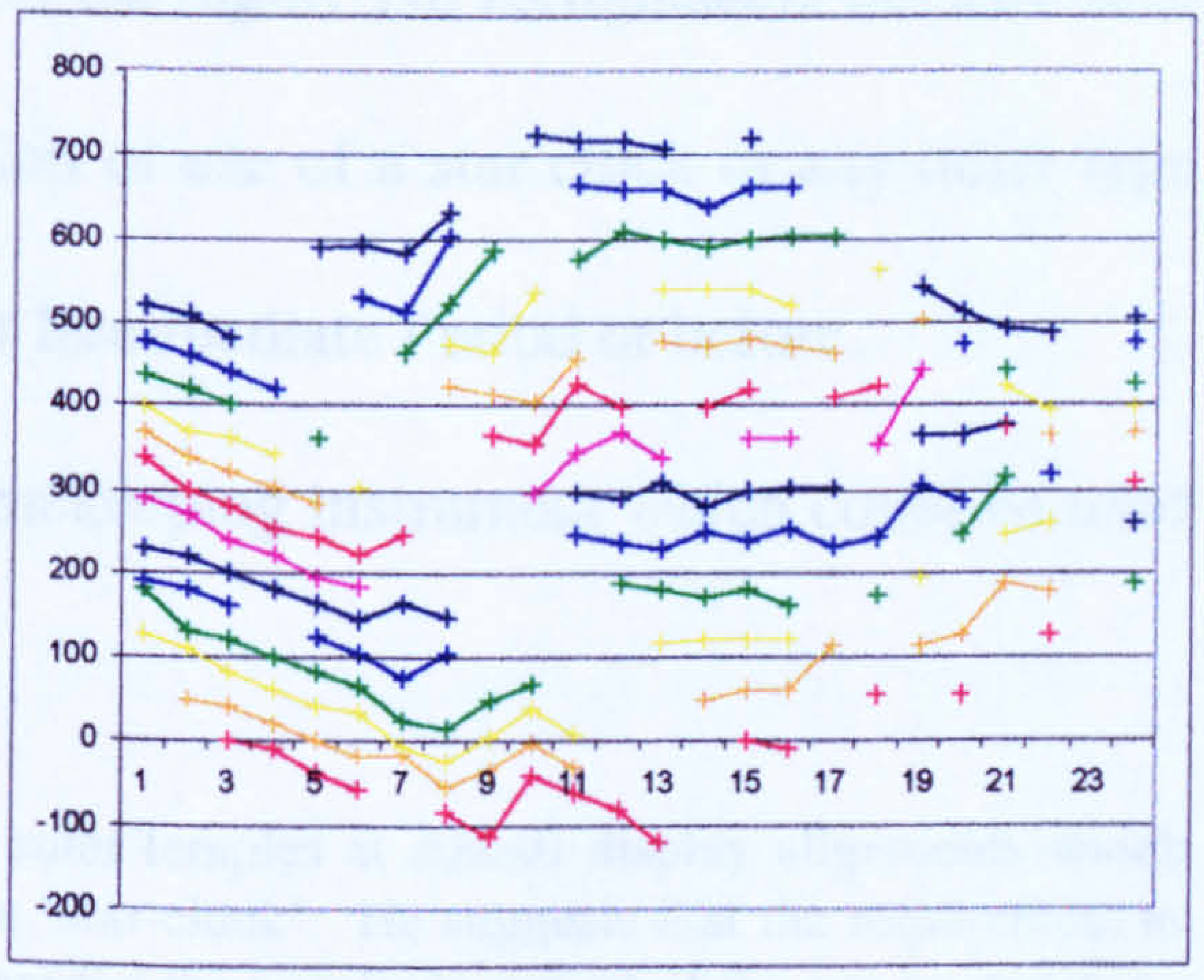
$\lambda = 60\ \mu = 40\ \omega = 60\ \delta = -10$



$\lambda = 60\ \mu = 40\ \omega = 60\ \delta = 10$



$\lambda = 40\ \mu = 60\ \omega = -60\ \delta = -10$



$\lambda = 40\ \mu = 60\ \omega = -60\ \delta = 10$

Figure 14: Hours of the night generated by the equations of Table 39

Section D: Development of Star Clocks

Diagonal Star Clocks

Although the *manufacture* of a star clock is not difficult, the *development* of such a procedure is not trivial. The motivation for the star clock table has always been stated to be to find the hour of the night. This statement implies that first, a need to find the hour of the night had been identified, and second that the particular method of a star clock table was chosen and developed to fulfil this need.

No other method of finding the hour of the night which dates from or before the time of these star clock tables has survived.[82] In particular, we can be fairly certain that no seasonally adjusted water-clock existed, because the record of that instrument's discovery has survived, and dates from the New Kingdom.[83] The only instruments that could be used to calibrate a new timekeeping method would be those which measured either a certain period of time which could be reproduced at will, such as burning a wick of certain length,[84] or some sort of water-clock which measured hours which were the same throughout the year, but were not necessarily of equal length throughout the night. No recognisable devices have survived, and no documentation about the invention or use of a star clock or any other type of timekeeping instrument is known from the First Intermediate Period or before.

It seems that the star clock was the first formal timekeeping instrument which could be used

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[82] Wells ('Origin of the hour') proposes that Vth dynasty solar temples at Abusir display alignments which suggests that their causeways were used as a reference for a 'star-clock'. He suggests that the requirement to perform sacrifices at dawn made it necessary for priests to predict the imminent arrival of the sun by watching the risings of bright stars. He proposes a system of twenty-four bright stars for each temple, which he lists, in order to give one hour's notice of dawn for fifteen days per star. As we shall see, the use of fifteen days in relation to nightly timekeeping did occur from at least 1850 BC, but no supporting evidence for Wells' theory has been found, nor for his assertion that the earliest hours measured using the stars were intended to be sixty minutes long.

[83] From the tomb of Amenemhet in Sheikh abd el-Qurna (time of Amenhotep I). Borchardt *Die Altaegyptische Zeitmessung* Table 18.

[84] Bierbrier *Tomb-builders of the Pharaohs* p. 50.

for finding the hours of the night. It first appears, fully developed to the extent of displaying mistakes and omissions characteristic of an established object, on the coffin lids we have been examining. No contemporary explanations nor earlier prototypes have been found.

It has been postulated that the motive for the tables was something other than timekeeping. De Puydt argues[85] that the tables 'may have just been an iconographic and textual rendering of the yearly motion of the star sky'. He supports this suggestion by noting that firstly, the tables only occur in tombs rather than in temples where he expects to find them if they were intended to be a practical timekeeping method, secondly, he has found 'no explicit evidence for nightly ritual or activity in general for which the precise measurement of the hours was needed', and thirdly, that there are 'too many variables in the behaviour of the star sky that the known structure of the star clocks cannot account for'. As he acknowledges, his first point can and surely must be explained by an accident of survival, in that the method was probably recorded on papyrus and kept in working libraries, whereas the corrupted copies which remain today were painted on wood and placed in tombs. His second comment indicates that a lack of obvious motive for the tables should be taken into account when analysing them, an approach which excludes the possibility that the modern researcher has not discovered or understood an Egyptian motive, and therefore would introduce an additional assumption into the field which seems both unnecessary and obstructive.

However, De Puydt's reluctance to assume that the clocks were intended *ab initio* as devices to find the hour of the night has merit. Previous studies[86] have examined the tables as isolated objects with hardly any reference to their development and motivation.[87] Discussion

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85 De Puydt 'Ancient Egyptian star clocks and their theory'.

86 Neugebauer and Parker, Clagett, Locher, etc.

87 Parker (*Ancient Egyptian Astronomy* pp. 53-54) attributes them to 'some genius in the early third millennium BC'.

of these points cannot, with the evidence now available, lead to definite conclusions about such matters as positive identification of decans but can shed some light on the purpose of the tables and the criteria that governed the choice of decans.

The appearance of Sirius as the decan of the twelfth hour occurs at, or during the period just after, the heliacal rise of Sirius. This event was certainly the most important stellar event in the Egyptian year due to its association with the annual inundation.[88] Theoretically, the heliacal rise of a certain star occurs on the same day of each 365¼-day year, until enough years have gone by for precession to have enough effect to change the date of the event. There are several possible reasons why the Egyptians did not alter the length of the year so that Sirius would rise heliacally on the same day each year. These reasons include administrative, political, and religious arguments. There is also the important and often overlooked reason that the heliacal rise of even a bright star like Sirius is a near-horizon phenomenon. Poor observing conditions, location, and human factors could combine to push the date of the event back from the predicted time of occurrence and obscure the fixed period between heliacal rises.[89]

Although Sirius gave warning of the flood's imminent arrival, the length of time between the appearance of the star and the rise of the waters varied considerably perhaps leaving it unclear which phenomenon of the two should take precedence as a time marker.

It is fairly certain that the behaviour of Sirius gives a model for all other decans. This is clear from Egyptian texts such as the dramatic text from the Osireion at Abydos.[90] In particular, that text states that decanal stars have a period of invisibility lasting seventy

[88] Parker *Calendars*.
[89] Schaefer 'Heliacal Rise Phenomena'.
[90] Frankfort *The Cenotaph of Seti I*.

days[91]. Sirius would theoretically have had this period of invisibility at the latitude of Egypt around 3500 BC,[92] if viewing was perfect and observations were carried out and averaged over several years (see Table 40[93]). The observational factors previously mentioned would tend to lengthen the period of invisibility, altering the hypothetical date of first calculation of the invisibility of Sirius to up to one thousand years later,[94] depending upon the quality of observational data used and the number of observations over which the period was averaged.

Date	Right Ascension (hours)	Declination (degrees)	Period of Invisibility (days)
AD 2000	6.7528	-16.718	63
AD 1500	6.3853	-16.134	63
AD 1000	6.0178	-15.813	62
AD 500	5.6503	-15.76	62
Year 0	5.2836	-15.975	62
500 BC	4.9181	-16.454	63
1000 BC	4.5533	-17.191	63
1500 BC	4.19	-18.177	64
2000 BC	3.8283	-19.404	65
2500 BC	3.4681	-20.859	66
3000 BC	3.1089	-22.529	68
3500 BC	2.4014	-24.401	70
4000 BC	2.3894	-26.457	72
4500 BC	2.0267	-28.679	74

Table 40: Position and period of invisibility of Sirius from 4500 BC to the present

There remains the question of how the star clock developed from the prototype behaviour of

[91] The earliest occurrence of the text is in the New Kingdom, far later (by at least one thousand years) than the origin of Egyptian interest in the motions of stars, therefore the use of the exact period of seventy days may be a later concept. The difficulty of dating the origin of the text means that the seventy-day funerary period and the seventy-day ideal invisibility of the decans cannot be considered absolute, however it is still certain that the invisibility of Sirius was significant.

[92] Using the heliacal rise and set prediction algorithm presented by Schaefer 'Heliacal Rise Phenomena' and hence converted into a computer program listed in Schaefer 'Predicting Heliacal Risings and Settings'. Schaefer's work on extinction and refraction ('Refraction by earth's Atmosphere' and 'Extinction Angles and Megaliths') also has implications for near horizon naked eye observations, though is more pertinent to the study of architectural alignments.

[93] Similar calculations were carried out by Ingham and presented in 'The length of the Sothic cycle'.

[94] This period (3500 BC to 2500 BC) ties in with the most likely of three possible dates for the establishment of the civil calendar based on an analysis of Sothic periods: 2781-2778 BC, given by Clagett (*Calendars, Clocks, and Astronomy* p. 31). Neugebauer's rejection of an astronomical basis for the foundation of the civil year (Neugebauer 'The Origin of the Egyptian Calendar' pp. 396-397) which leads Clagett to date the introduction of the calendar to c. 3000 BC still lies within our estimate of the time period during which the disappearance of Sirius lasted '70 days', as does Parker's estimate (based on an average lunar year) of c. 2937-2821 BC. The date of the introduction of the civil calendar is significant to the present argument because it would only be after the introduction of the civil calendar that counting days in packets of ten would become natural.

Sirius.

Seventy days is not only the length of the invisibility of Sirius, but is also the time set aside for funerary preparations after the death of an important person. By the time of the *Coffin Texts* and the rising star clock tables, the nobility could aspire to an existence after death which was very similar to that reserved for the pharaoh alone during the time of the *Pyramid Texts*. Sections of the *Pyramid Texts* illustrate the close links between death and the stars,[95] for example in Utterance 302 which begins 'The sky is clear, Sothis lives,[96] because I am a living one, the son of Sothis,[97] and the Two Enneads have cleansed themselves for me in Ursa Major, the imperishable. My house in the sky will not perish, my throne on earth will not be destroyed, for men hide, the gods fly away. Sothis has caused me to fly up to the sky into the company of my brethren the gods, Nut the great has uncovered her arms for me...', while Utterance 442 states 'You will regularly ascend with Orion from the eastern region of the sky, you will regularly descend with Orion into the western region of the sky'.[98] These links continued through to the New Kingdom,[99] as evinced by the astronomical ceilings of New Kingdom royal tombs, and beyond. The Duat, frequently translated as the 'Netherworld', was essentially a celestial domain which surrounded the material world.[100,101] The stars were visible to living man, but unreachable and intangible. The horizon was a liminal region, a gateway to the Duat, as was the tomb.

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[95] For a collection of stellar references see Faulkner 'The King and the Star-religion in the Pyramid Texts'.

[96] i.e. is visible (Faulkner *Pyramid Texts* Utterance 302, Note 1).

[97] i.e. also a star (Faulkner *Pyramid Texts* Utterance 302, Note 3).

[98] Both exerpts are Faulkner's translations from his *Pyramid Texts*.

[99] Portions of the *Pyramid Texts* themselves, as well as texts clearly based on parts of the *Pyramid Texts*, were still being used as tomb, coffin, and shroud texts throughout Egypt during the New Kingdom (Allen *Occurences of Pyramid Texts*).

[100] There is a clear distinction between the visible sky and the Duat. For example, consider the passage from the Great Hymn to Aten (Davies *The Rock Tombs of El Armana* Part 6, translation in Lichtheim *Ancient Egyptian Literature* Vol. 2) where Aten made three Niles: one in the Duat, one in the sky (rain, associated particularly with foreign lands), and one on earth. This text effectively divides creation into three regions: the spiritual realm, the foreign lands, and the physical Egypt, but also highlights the fact that the tangible sky *pt* was not the same as the Duat.

[101] The Osireion itself was thought to have a special connection with the Duat, as evinced by a graffito there which refers to Osireion as *tꜣ štꜣ n dꜣt* 'secret land of the Duat' (Frankfort *Cenotaph* Graffiti 3 pl. LXXXVIII).

It is possible that the use of the decans to mark the hours was a by-product of another, more immediately practical, activity: marking a period of days. If the death and burial of a person can be likened to the disappearance and heliacal rise of a star, then the period between death and burial can similarly be linked to the period between the disappearance and reappearance of a star. This idea leads to a hypothetical course of development of the rising star clock which is outlined below.

The link between the number days of funerary preparations and the disappearance of a star provides the motivation to create a list of stars and the dates of their disappearance and reappearance, with the goal of finding stars with a period of invisibility of around seventy days. If observations were begun on that basis, it would become apparent very soon that the magnitude of the task was very large. Some short cuts would be needed to simplify the work and the end product. Firstly, the brightest stars would be the easiest and most obvious to observe.

Another fairly obvious simplification would be to assume that a star that disappeared a certain number of days after Sirius would reappear that same number of days after the heliacal rise of Sirius. This assumption is not true: a combination of declination, magnitude, and position of the sun govern the period of invisibility of a star.[102] If this assumption were made, the stars chosen could be located at various declinations in the sky and not form a 'belt'. Conversely, if the periods of disappearance were carefully checked, the chosen stars would lie on a certain belt or region of the sky, which Neugebauer and Parker have calculated and plotted.[103]

A limit would have to be set on the number of stars used. Using one star per day would need

[102] Schaefer 'Heliacal Rise Phenomena'.
[103] *Egyptian Astronomical Texts* 1 p. 100 fig. 27.

a list of 365 stars. Bright stars are not frequent so a list this long would contain very faint stars and also gaps where no star was suitable. One star per month is too long in comparison with the seventy-day period which was to be measured. Some frequency between one day and thirty days would be chosen.

Exactly how each star was selected is not known, but a combination of magnitude, familiarity, period of disappearance, and a certain amount of human error and leeway would allow a list to be made with a reasonable amount of ease.

In order to use the list of stars for the original purpose it was intended, one would find on the list the star which disappeared on or around the date of death. The reappearance of that star would mark the time of burial, or of the deceased's entrance to the Duat, or some other important moment in the existence of the dead.

The transformation of this list of star names (the prototype of a decan list) and dates into a star clock requires the addition of a new axis marked in hours and some observation of the movements of the listed stars after their reappearance. Very few observations would be needed to produce the diagonal pattern which is characteristic of the clocks.

The fact that in most of the existing clocks[104] twelve hours are marked off during the night is related to the choice of ten days as the interval between the heliacal rising of one decan and the next. It is not certain which period (ten days or one hour of twelve) was the major consideration when making the clock, although the number of hours is generally considered to take precedence. However, if the development of the star clock followed the course outlined above so that an 'hour clock' was a by-product of a 'day clock', the opposite may

[104] A10 and A14 mark only eight hours, while A16 shows only ten. A10 is too garbled to ascertain whether this is due (most likely) to space considerations or whether only the middle eight hours were being used (like the Osireion shadow clock). A14 is well ordered and appears to represent the second to ninth hours, when compared with A13. A16 does not appear to represent a subsection of another table and is somewhat disordered.

be true.

An important feature of this hypothetical procedure is that the events that happened to the dead person were regulated by the stars and not by the sun nor by any other means of marking time used by living people. This ties in with the location of the surviving star clock tables which were painted on the inside of the lids of coffins or later, as will be discussed, on the ceilings of funerary monuments.

We have now described a hypothetical scenario which provides a motive and a method for the creation of a list of star names that measured time primarily in days but could also be made to measure the hours of the night.[105] The development of the hypothesis has highlighted some important points about the star clock tables.

Firstly, it is unlikely that the decans first appeared in the format of a star clock table. This mirrors the fact that decans continued to appear as a cohesive, important group long after the entire genre of star clocks was extinct.

Secondly, since near-horizon observations[106] are inherently prone to inaccuracy and variation from one year to another and stars are not uniformly distributed across the sky, the star clock was not developed in the atmosphere of precision to which we in modern times are accustomed. Also, the choice of stars that fit certain criteria is subject to human interpretation. Consequently, star clocks do not yield to stringent analysis as much information as we would expect from a timekeeping instrument. We saw that this was also the case with the Ramesside star clock which is capable of producing a mass of meaningful-looking equations without supplying very much of an insight into what criteria were used to construct the clock.

[105] Both Krauss ('Astronomische Konzepte') and Locher ('Middle Kingdom astronomical coffin lids') have previously expressed theories that the decans evolved from 'seasonal' markers to 'hour' markers.
[106] Schaefer 'Refraction near the horizon', 'Extinction Angles', and 'Heliacal rise phenomena'.

Thirdly, the Egyptian concept of 'hour' does not correlate exactly to any modern concept of 'hour'. We have seen how the surviving diagonal star clocks from coffin lids were not labelled with hour names and how the Osireion passage star clock used the word *sp* instead of *wnwt*. In the analysis of the timekeeping properties of each device we have not found a uniform hour among them.

These three observations indicate that neither the identification of the tables wholly as an (intended) accurate timekeeping method, nor the view that the tables had no function at all other than symbolism, is representative of the available cultural and physical evidence. The truth, if we ever have evidence enough to discover it, will probably be somewhere in between. It is this lack of definition that leads to difficulties when identification of decans is undertaken without more information about the development and use of the tables.

From the earliest postulated use of the decans, through the New Kingdom and beyond, the impression remains that each timekeeping method, and probably each individual timekeeping device, *defined* time. This is a vitally important point because it alters completely the way we must approach these objects. In many studies, especially those related to the Karnak water-clock, the emphasis has been on the question: 'How accurately did this object tell the time?' If the device was obviously not tailored for equal hours throughout the year, the Greek alternative of seasonal hours was immediately adopted as the system of choice for examining, and ultimately judging, these Egyptian devices.

This type of assumption leads to an instant distancing of the researcher from the objects. For each timekeeping method such an approach must always begin with the problem of calibration. Texts such as the Eber's papyrus and the autobiography of Amenemhet show that some knowledge was collected about night length, but neither of these texts offers enough evidence to state that tables of hour lengths throughout the year existed.

The water-clock is always the favourite candidate for calibrating other timekeeping devices. It is an attractive idea perhaps because water-clocks are the most immediately comprehensible timekeepers to the modern mind. To this end, researchers have proposed that water-clocks provided calibration for diagonal star clocks and were also used in the daylight hours to calibrate sundials. Without further insight into the nature of hours measured by both water-clocks and astronomical timekeeping methods, such theories cannot be proved.[107]

These points, raised by discussion of the development of the first type of star clock, will continue to be pertinent throughout this discussion of the development of timekeeping methods.

The 'Transit Star Clock'

The accepted chronology of timekeeping in Egypt places the 'transit star clock' as a development and improvement of the diagonal 'rising' star clock. The reason for this order of events is obvious: surviving diagonal star clocks pre-date the two surviving 'transit star clocks'.

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[107] Only one water-clock dating from the New Kingdom has survived. The decoration of the Karnak water-clock will be discussed in Section H, but its timekeeping abilities have been analysed and discussed at length by many researchers. (See articles by Balmer; Cotterell, Dickson, and Kamminga; Fermor, Burgess, and Przybylinski; and Sloley). Approaching the object from the point of view of accuracy, hydrodynamicists are hampered by the lack of a spout in the preserved portions of the vessel. The nature of the spout is critical to calculations of rate of flow and hence accuracy in measuring seasonal hours.

During the course of this study, a replica of the Karnak water-clock was constructed by Dr Allan Mills of the University of Leicester, and decorated by the present author who also had the opportunity of experimenting with the vessel before it was placed on display at Leicester's New Walk Museum. Using various diameters of holes in copper foil (therefore differing from researchers who have used tubes such as hollow needles) the rate of fall of the surface of the water was found to be constant. This directly contradicts predictions by other researchers who have found that the truncated conical surface of the Karnak clock only approximates the curve required for a constant rate.

However, despite the observation that the Karnak vessel could, under certain conditions with a specific type of jet, measure equal time periods, the study of this particular example's timekeeping is defeated by the fact that the hour marks inscribed on the inner surface are not equally placed.

Without further New Kingdom examples, it is impossible to say whether the marks were placed with care, or whether the shape of the vessel was particularly chosen, or whether both these considerations are fortuitous and unique to this one example.

The 'transit star clock' offers two potential areas for increasing the accuracy of the star clock. Firstly, the observations would be removed from the horizon area, eliminating many observational difficulties, and secondly, using the meridian (a great circle) as datum would allow equal hours to be measured with ease. However, both of these reasons stem from a modern desire for accuracy, and almost certainly do not reflect Egyptian timekeeping priorities.

From the argument above for the evolution of the diagonal star clock from a list of stars created to measure the passage of days, we can see that the date list contained within the *Book of Nut* resembles more closely an embellished list of this type (with the event 'First' being added to the necessary 'Enclosure' and 'Birth') than an improved diagonal star clock.

The survival of a descendant of the original form of date and star list to the New Kingdom is certainly not an impossible concept, especially when it occurs in the Osireion complex where a type of diagonal star clock also was used as decoration for another ceiling.[108] The unique nature and location of the Osireion makes it likely that decoration for the building was chosen to represent the oldest available knowledge. Texts which might have seemed archaic at the time of the construction of the Osireion would be copied out for use in decorating the walls and ceilings, and these copies, one can imagine, may have been the inspiration for the use of the *Book of Nut* in the Tomb of Ramesses IV.

A date for the star calendar can be obtained from the heliacal rising of Sirius. By presuming that date set 35 relates to *spdt*, Neugebauer and Parker[109] saw that 'Birth' occurred on IIII Peret 16, which places the date list in the Middle Kingdom, around 1850 BC, and implies that the date list, and hence any timekeeping method it represents, could have been more

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[108] The Sloping Passage clock, source B1.

[109] *Egyptian Astronomical Texts* 2 p. 54.

than five hundred years old at its incorporation into the decoration of the Osireion. Leitz[110] argues for a much earlier date. He combines an earlier year for *prt spdt* on IIII Peret 16 = 16th July, a 70-day period of invisibility of Sirius, and culmination of Sirius at midnight on I Akhet 1 to arrive at a date of around 3323 BC for the compilation of the date list. This date cannot be confirmed: the use of 'culmination' and 'midnight' is problematic, and there are difficulties associated with determining an era for the basis of the 70-day period of invisibility of Sirius which were noted at the beginning of this section.

What is indisputable is the remarkable survival of the *Book of Nut* into the present era in the form of Papyri Carlsberg 1 and 1a (which date from the second century AD) although the star calendar text is not preserved in these documents. If a text can survive from the New Kingdom to Roman times, it is certainly possible that the basis for, or even the original of, that text pre-dates its earliest surviving occurrence, and that the method the text describes may be even older.

It is therefore conjectured that the star calendar in the *Book of Nut* is an embellishment of a list of stars which displayed a common period of invisibility, and as such is not an improved diagonal star clock.

For this conjecture to be given credence, it is necessary to review the evidence which has previously been put forward in support of the 'transit star clock' which Neugebauer and Parker describe.

In the first instance, the fragmentary list of decan names associated with the date list has already been shown to have only circumstantial links with later decan lists. Also, none of these later lists is found in conjunction with a timekeeping method, so no support is lent to the transit clock theory from that quarter.

[110] Leitz *Studien zur aegyptischen Astronomie 1* p. 52.

Far more important is the identification of the event 'First' or *tpt* with a concrete, observable astronomical event: the transit of a star across the meridian at the end of the first hour of the night.

This behaviour, meaning the transit marking the first hour of the night 200 days after 'Birth', is true of Sirius, which has a visual magnitude of –1.60, but does not hold for fainter stars. Although the time of transit in relation to the time of sunset (the condition for 'First Hour') is not dependent on magnitude, the date of 'Birth' certainly is. Therefore, if Sirius were in exactly the same position, but was a star of magnitude 1.0, the date of 'Birth' would be five days later. Similarly, if Sirius had a magnitude of only 3.0, the date of 'Birth' would be 17 days later. It is also possible that some decans are fainter than the third magnitude. A difference of 10 days at 'Birth' means that transit at the date given by 'First' occurs one Egyptian 'hour' later than required, and a difference of 20 days at 'Birth' means that transit at the date given by 'First' occurs two Egyptian 'hours' later than required.

There is, therefore, an inherent problem with the date list if it is to be used as a star clock in the manner which Neugebauer and Parker suggest. The observer would have his meridian set up using an external reference for south and a *mrḫt* for a sight line,[111] but the stars would not behave as expected with regards to the position *tpt*. 'Birth' and 'Enclosure' would be correct, but the information on which the identification of the date list as clock rests does not

[111] See Larson 'The Tutankhamun Astronomical Instrument'. The instrument was described by Breasted as 'A rectangular strip of ebony wood a little over 10½" long ... 1 1/16" wide, thickness just ½". ... At one end of the ebony strip is a rectangular mortise hole a little over half an inch long, about 3/16" wide, and a scant ¼" deep.' Berlin Museum Inv. Nr. 14084 is also mentioned, which is inscribed 'A watching stick for determining a festival and for placing all men in their hour(s) ...'. The article states that 'Using simple tools such as these, and by keeping careful records of their star observations, Egyptian astronomers were able to predict when a particular star would cross a meridian.' However, the *mrḫt* may well have been a daytime shadow timekeeping instrument rather than a night-time meridian instrument. Section E will deal with shadow clocks which resemble *mrḫt* in every way, but have marks on their upper surfaces which mean that they can be used as sundials. Surviving shadow clocks are of stone with engraved marks, but it is possible that wooden *mrḫt* may have had painted marks and may have been used as sundials.

hold.

The existence of this problem is a direct result of the assumption that the event 'First' occurred on the meridian. No clear evidence exists which proves that the Egyptians had defined this imaginary line on the sky in the New Kingdom. Its place in Egyptian astronomy derives from two occurrences only: the 'transit star clock' and the Ramesside star clock. We have already seen that the meridian was simply a convenient modern object to tie to the '*r ꜥḳꜣ ib*' position of the Ramesside star clock. The phrase *r ꜥḳꜣ ib*, 'straight forward' is the only term that has been postulated to mean 'on the meridian'. Both the Ramesside star clock in the conventional usage and the 'transit star clock' need, in order to work, a precise definition of the meridian, yet we have identified no term for it and no external references have been proved to relate to the meridian.[112]

The meridian appears to have been introduced into Egyptian astronomy by modern researchers, intent on pinning down the ancient timekeeping devices by placing them within the framework of modern astronomical terminology.

Finally, some major evidence which has been used to support the theory of the transit star clock comes from the two papyri Carlsberg 1 and Carlsberg 1a dating from the second century AD. These are copies of a commentary on the *Book of Nut,* and are apparently written in the same hand.[113]

It is a great pity that the portions of the papyri which would have held the Nut vignette have not survived. It is possible that they may have contained a full list of decans to accompany the date table which would be of great interest to the current discussion.

The surviving portions of the papyri include an interpretation of the text labelled 'U_4' which

[112] See also Žába *L'Orientation Astronomique*. Parker ('Ancient Egyptian astronomy' p. 51) gives only one occurrence of a term for culmination (that is a star crossing the meridian): in the Harkhebi inscription (*Egyptian Astronomical Texts* 3 pp. 214-216). However the text is 'astrologically flavoured' and displays Babylonian influences.

[113] In the discussion which follows, we shall use the term 'scribe' for the author of the original commentary. This may or may not be the same person as the copyist of the papyri, but this is not pertinent to our discussion.

uses the word 'working' for the period 120 days before 'First' for each star. The nature of this 'working' is not fully explained within the text, but it is implied that the star marks the first hour of the night for ten days before the date called 'First', the second hour of the night for the ten days before that, and so on up to the twelfth hour for the first ten days of the 120-day 'working period'. This implies a timekeeping structure similar to the Ramesside star clock, omitting only the 'beginning of the night'.

The scribe breaks the year of a typical star[114] into the following sequence of events:

	110 days work
IIII Akhet 26 begins to work	
	10 days work
'First' I Peret 6 stops work	
	90 days in the west
'Enclosure' IIII Peret 6	
	70 days in the Duat
'Birth' II Shemu 16	
	80 days in the east

In contrast, text V simply states that there are '29 [decans] living and working in heaven' and gives no further information about 'working'.

Neugebauer and Parker infer[115] that the 120-day working period mentioned in the papyri is the 'working' [*bꜣk*] referred to in the Osireion version of the text labelled V and hence that the date list was regarded, from the New Kingdom onwards, as a star clock, a device for finding the hour of the night.

That the scribe of Papyri Carlsberg 1 and 1a understood the *Book of Nut* to be a star clock is a point which needs to be addressed. There are two possible explanations for the scribe's comments: he is either forming his conclusions from his experiences of other timekeeping methods, or he had access to a more complete source. That the scribe had difficulty with understanding the *Book of Nut* is clear from the way he attacks the texts from the diagram. For example, as we shall see in the section dealing with the *Book,* he reads the diagram in an

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114 The scribe names the star as *pḥwy ḏꜣt*, but reconstruction of the decan list makes the dates those of either *tmꜣt ḥrt ẖrt* (as Neugebauer and Parker noted) or *tmꜣt ḥrt*, not *pḥwy ḏꜣt*.
115 *Egyptian Astronomical Texts* 1 p. 56 commentary 44.

illogical order. His explanations are not clearly stated and are sometimes obviously wrong.[116] The scribe, it must be remembered, was around fifteen centuries removed from the Osireion text (and up to two thousand years removed from the original text) and so cannot be assumed to be an expert on the original meaning of the text. This makes it possible that he was indeed forming his own understanding of the text using outside information. Conversely, we have already noted that the *Book of Nut* as preserved in the Osireion and the tomb of Ramesses IV is an incomplete document and it is therefore possible that the scribe had a fuller version of the text. However, it is notable that, if this is the case, no mention is made of any decans which we do not see preserved in the New Kingdom version, and also the scribe does not allude to any other hours of the night in the context of timekeeping, which may have helped him clarify his description. This may indicate that the former case is more likely, but it cannot be determined which of the two possibilities, if either, is true.

In conclusion, from the New Kingdom sources only, we find that the date list in itself is not sufficient to find the time during the night. Firstly, the decan list included with the date list in the *Book of Nut* is too fragmentary to permit the use of the date list in such a way. Secondly, the information contained within the date list and its arrangement does not lend itself to this use.

It seems prudent when trying to determine the nature of the date list first presented in the New Kingdom to allow New Kingdom sources the primary focus. The label *tpt* can surely be taken to mean *wnwt tpt* 'First Hour' with the meaning 'beginning of the night', without implying that the entire table as it stands should be interpreted as a clock. It has also been suggested[117] that the 120 days related to *tpt* simply represent the period of time during which a star culminates during the hours of darkness. If 'culmination' is taken in a general sense of

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116 See Section F for a full discussion of the *Book of Nut*.
117 De Puydt 'Ancient Egyptian star clocks' p. 9.

the highest altitude a star attains, rather than in the precise definition of transiting the meridian, this provides a meaning for the third event in the star's year: disappearance, reappearance, and attaining greatest height at the beginning of the night. Such a rough definition of *tpt*, and of 120 days working is more in keeping with the nature of the list as a calculated, rather than observed, description of annual events.

It may still be that a true and complete star clock based on the movements of the decans away from the horizon area existed during the New Kingdom and was the basis or a parallel for this text, but the *Book of Nut* does not contain the entirety of such a device.

The existence of a method for determining the hours of the night using the transits of decans across the meridian has been disputed and we now see that the *Book of Nut* star calendar is not necessarily a direct descendent of the diagonal star clock but is more closely related to the precursor of the diagonal star clock, a list of stars which disappeared for seventy days.

Ramesside Star Clock

The final type of star clock that we have examined is the Ramesside star clock. We have discussed at length the problems of interpreting this type of star clock. We now have one further piece of information: that the existence of transits as a timekeeping method prior to the Ramesside star clock has not been established. In particular, this means that the meridian itself has not been proven to be a recognisable and well-defined object within Egyptian astronomy. This lends credence to the idea that the central position *r ꜥḳꜣ ib* which is used in the Ramesside star clock may not be the meridian as we understand it.

By comparing the date of 'First' for *spdt* in the transit star clock (assumed to be contained with date set 35) and the occurrence of *sbꜣ n spd* as the beginning of the night star in T12 of the Ramesside star clock, Neugebauer and Parker estimate the date of the Ramesside star clock to be around 1470 BC.[118] This date must be treated with caution[119] since it is not

[118] *Egyptian Astronomical Texts* 2 p. 9.

certain that the hour star *sb3 n spd* is exactly the same as the decan *spdt*,[120] and also it is not certain that the definition of 'beginning of the night' can be equated between the two methods. Leitz[121] suggests an exact date of 1463 BC.

Concerning this last point, it is clear that the nature of hours marked by the two types of star clock must be different if *sb3 n spd* is equivalent to *spdt*, since *sb3 n spd* is *r ꜥḳ3 ib* at the end of the second hour thirty days from its appearance as 'beginning of the night' whereas the 'transit star clock' places the star at the end of the second hour only twenty days before 'First'. The date found by Neugebauer and Parker therefore remains questionable.

It is easy to see the similarities between the 'transit star clock' method and the Ramesside star clock used in the conventional way: both make use of the *mrḫt*, both use the meridian. It is difficult to see, however, what improvement the Ramesside star clock offered over the transit star clock that caused the later method to be developed. The Ramesside star clock needed an extra observer, larger tables, and a new set of stars. The Ramesside star clock could not be used from memory in the way the diagonal star clock or a 'transit star clock' had the potential to be used.

We postulated in the last section that some timekeeping method existed that used the decans while they were high in the sky, but was not based on the modern concept of the meridian. We see that the Ramesside star clock used by the reflection method would be a device of this type, using a somewhat different set of stars we call 'hour stars'.

If the notion of 'meridian' is removed from the two timekeeping methods, their relationship

[119] Fermor ('Perceived night length ratios in ancient Egypt') disagrees with Neugebauer and Parker's date of 1470 BC (*Egyptian Astronomical Texts* 2 p. 9) and believes that an earlier date cannot be ruled out, while De Puydt ('Ancient Egyptian star clocks') believes that the tables mark risings rather than transits and so dates them to c. 1200 BC, bringing the time of creation closer to the date on which the tables were painted on the tomb ceilings (note that he mistakenly places the tables on the walls of the tombs). His arguments for this interpretation include counting the number of stars between certain events (such as T24·0 to T1·12 equals 23 stars) to estimate night length but this approach is hampered by the fact that the distribution of hour stars is unlikely to be even (as is the probable case with decans).

[120] See Leitz *Altaegyptische Sternuhren*.

[121] Leitz *Altaegyptische Sternuhren* pp.132-137.

also falls apart. The discussion of the 'transit star clock' left us with only a hypothetical instrument to examine, and its replacement, also hypothetical, with a timekeeping instrument that existed at the time of writing of the *Book of Nut* which used decanal stars at some altitude above the horizon, gives us no link with the Ramesside star clock which has previously been held to have followed it.

As a timekeeping method which probably did not survive in any form, except in the tombs of the Ramesside kings, after the end of the XXth dynasty, the Ramesside star clock seems to be a unique device, not an improvement or embellishment of an existing method, but an entirely new instrument.

The reasons for constructing the new tables are not certain, but the observational method is capable of reproducing hours which varied throughout the year, and indeed throughout the night. It is tempting to suggest that the new stellar method was created to reflect a development in the manufacture of water-clocks (Amenemhet's invention of the seasonal water-clock occurred just before the suggested date of origin of the Ramesside star clock tables) or was due to the New Kingdom interest in describing the hours of the night in funerary literature.

A Chronology of Stellar Timekeeping

We have so far constructed a sequence of events and developments that fits well with the available evidence, and offers us a structure within which to place stellar timekeeping methods (Table 41). Many of the dates in this schematic chronology, as already discussed, are open to other interpretations. The chronology illustrates the patchy nature of our sources, and the likelihood that our sample of astronomical texts is probably too small to be completely representative of the range of material which originally existed.

We find that the chronology breaks into four sections: the early development of the decanal system, which we know very little about; a period of using the decanal system on coffins, during which revisions were made and towards the end of which the date list preserved in the *Book of Nut* was compiled; then the New Kingdom, where old texts and methods were reused without revision, the Ramesside star clock was developed, and celestial diagrams were either introduced, or were first used in places where they have survived in numbers; and finally, through the remainder of Egyptian civilisation, the decans become symbolic remnants.

The survival of the *Book of Nut* into the second century of the present era has already been remarked upon, but it is only the most spectacular instance in a history of documents being kept for centuries before they were used to decorate a monument or object which has survived.

Sirius disappeared for seventy days	*after 3500 BC*
Possible date for basis of Book of Nut date list	*c. 3323 BC*
Stars were chosen with invisibility of 70 days (the customary funereal period)	*?*
Stars were used to find hour of the night at rising (causing the introduction of triangle)	*?*
A triangle had been compiled	*by 2640 BC*
Revision of star clock resulting in A1 to A9, A15 to A17	*2150 – 2000 BC*
Triangle for celestial diagrams formed	*2000 – 1800 BC*
Revision of star clock resulting in A10 to A14, B1	*1990 – 1760 BC*
Decans were used to find hour of the night while high in the sky	*? if ever*
Possible date for construction of Book of Nut date list, β	*1850 BC*
Ramesside star clock constructed	*1450 BC*
Osireion built and decorated with Book of Nut	*1300 BC*
Sloping Passage star clock using B1	*1220 BC*
Tomb of Ramesses IV	*1160 BC*
Ramesside star clock in Valley of the Kings	*1150 – 1100 BC*
Decans used as group in celestial diagrams	*1460 BC – AD 100*
Carlsberg 1 and 1a	*AD 150*

Table 41: A chronology of stellar timekeeping in Ancient Egypt

Section E: Shadow Clocks and Sloping Sundials

Introduction

Egyptian shadow clocks are small instruments consisting of a horizontal base rod of rectangular section with a vertical block at one end. The base rod is inscribed with small circles making up an hour scale. The vertical block has a hole and reference line suitable for the attachment of a plumb bob. The top surface of the block can contain holes or indentations.

In 1910 Borchardt[122,123] proposed that the surviving shadow clocks were incomplete, and that an additional element in the form of a crossbar (a rod of similar dimensions to the base rod attached at its mid-point to the top face of the vertical block and extending horizontally at right angles to the scale) was originally part of each shadow clock.

In this section, the shadow clock will be examined using extant examples and texts which describe or depict this type of timekeeping method. Borchardt's theory will be extensively discussed.

A second type of sundial, the 'sloping' or 'Egyptian' sundial, dating from the Late Period will also be discussed, in particular with reference to the development of this method and the connection between the earlier and later types of sundials.

Sources

E1 Berlin Aegyptisches Museum Inv. Nr. 19744[124]

E2 Osireion Text, part dealing with the shadow clock headed by a diagram[125]

E3 Berlin Aegyptisches Museum Inv. Nr. 19743[121]

E4 Tanis papyrus[126]

E5 Qantara sloping sundial[127]

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122 Borchardt 'Altägyptische Sonnenuhren'.
123 Borchardt *Zeitmessung*.
124 Details of the two Berlin instruments are provided in Borchardt 'Altägyptische Sonnenuhren'.
125 Frankfort *The Cenotaph of Seti I.*
126 Griffith and Petrie *Two Hieroglyphic Papyri.*
127 Clédat 'Notes sur l'isthme de Suez' and Kuentz 'Notes sur un gnomon portatif Gréco-Égyptien'.

The list of objects above is not exhaustive, other sundials and artefacts presumed to be part of sundials have survived and are in collections around the world.

The shadow clock first appears at the beginning of the New Kingdom. It is probable that the shadow of the sun had been used to mark time periods long before this time,[128] but these devices would have been informal, non-standardised objects, perhaps resembling the basic sundials seen in pastoral societies around the world.[129] The shadow clock is the earliest sundial used in Egyptian society that has some surviving documentation and aspects of standardisation.[130]

E1 is inscribed with the name of Tuthmosis III. The base rod has five circles making up an

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[128] The Middle Kingdom *Prophecy of Neferti* alludes to the connection between shadows and timekeeping. Parkinson (*Voices from Ancient Egypt*) translates the relevant passage as:

> 'Re withdraws himself from mankind
> Though he shall rise when it is time, it shall not be known when midday occurs;
> there is no one who can distinguish his shadow, no one's face is bright when (he) is glimpsed'

[129] See Floyer 'Primitive Sundials in Upper Egypt'.

[130] There are a few other candidates for solar timekeeping in the New Kingdom and later. In particular, obelisks are often cited as giant sundials. This attractive theory is let down by obelisk inscriptions which state clearly what the obelisks were for. Hatshepsut even predicts that future admirers of her obelisks may wonder what their purpose was, and preempts their guesses saying:

> 'Now my heart turns to and fro,
> In thinking what will the people say,
> They who shall see my monument in after years,
> And shall speak of what I have done.
> Beware of saying, "I know not, I know not:
> Why has this been done?
> To fashion a mountain of gold throughout,
> Like something that just happened."
> I swear, as I am loved of Re,
> ...... as regards these two great obelisks,
> Wrought with electrum by my majesty for my father Amun,
> In order that my name may endure in this temple,
> For eternity and everlastingness,
> They are each of one block of hard granite,
> Without seam, without joining together!'

(Lichtheim *Ancient Egyptian Literature Vol. 2*)

Until recently it was thought that a white limestone model in the Egyptian Museum in Cairo (No. 33401) was a type of stepped sundial combined with a sloping sundial and a shadow clock. Clagett follows Borchardt's identification of the object as a timekeeping device, even after commenting that the theory requires the 'sloping sundial' portion to be used in an east-west orientation, which he knows to be highly unlikely. It is now widely accepted that this object is a base for an architectural model. Also recently discredited is the assertion that a small ivory disk from Gezer in Palestine (published in Macalister *The Excavation of Gezer* and described as a sundial in Borchardt *Zeitmesseung* and Sloley *Primitive Methods of Measuring Time*) which bears a cartouche of Merneptah on one side and some radial marks on the other, is a New Kingdom vertical sundial.

hour scale. If the length between the vertical block and the first circle is called 1 unit, then the length between the first circle and the second is 2 units, between the second and the third is 3 units, between the third and the fourth is four units and between the fourth and the fifth is 5 units. This ratio 1:2:3:4:5 is also displayed by the other example in Berlin, which is around 500 years later in date.

Figure 15: Shadow clock from the time of Tuthmosis III (E1)
(from an Aegyptisches Museum photograph)

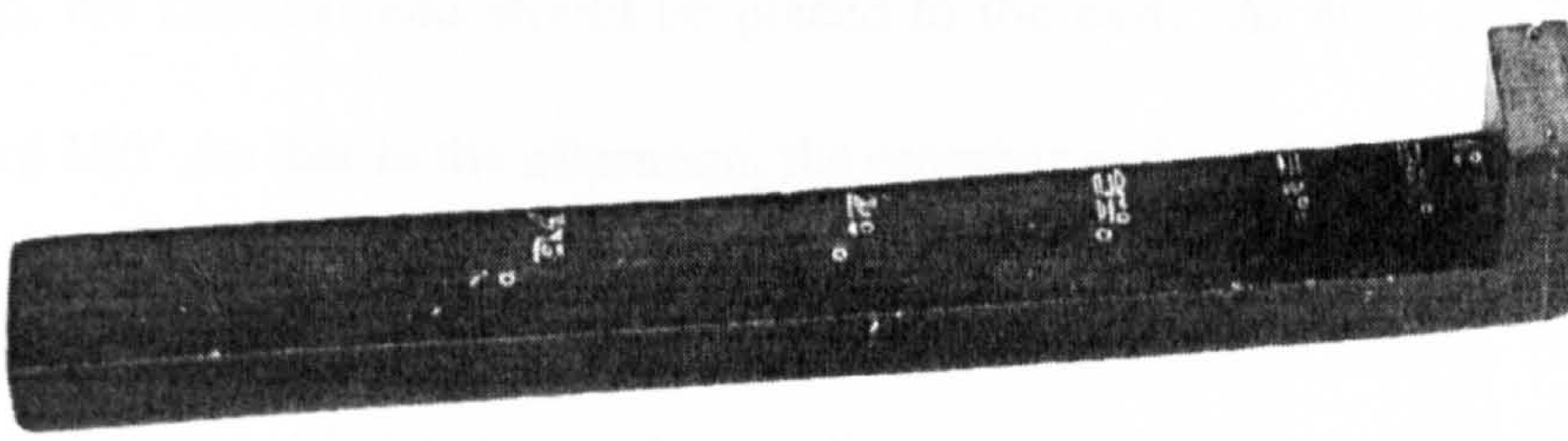

Figure 16: Shadow clock from Fayum (E3)
(from an Aegyptisches Museum photograph)

The ratio is also present in a New Kingdom text, the *Book of Nut*, in the version which appears in the Sarcophagus Chamber of the Osireion at Abydos. The other parts of the *Book of Nut* will be dealt with in a later section. The part pertinent to the shadow clock which we refer to here as source E2 is reproduced in Figure 17. In the diagram which heads the text, the characteristic L-shaped body of the clock is depicted. Five vertical short lines issue from the base rod and above the spaces between these lines are the numbers 3 (closest to the vertical block), 6, 9, and 12.

Although the vertical marks are roughly evenly spaced, comparison with the existing instruments indicates that the numerals relate to the distance between the marks. Of course the ratio 3:6:9:12 can be reduced to 1:2:3:4, the ratio which we noted for the Tuthmosis III instrument. Also, although the diagram shares with the Berlin shadow clocks the five marks, the surviving shadow clocks do not have the unlabelled gap between the vertical block and the first mark, the distance from the block to the first mark is 1 unit, whereas in the Osireion text it is '1 unit' from the first mark to the second.

The Crossbar Hypothesis

Borchardt first postulated the addition of a crossbar in order to make sense of the hour marks on the two instruments in Berlin. With the addition of a crossbar of a certain height,[131] Borchardt claimed that the sundials could be made to mark seasonal hours. The theory stipulated that the instrument be used in a certain manner, being aligned exactly east-west. In the morning, the crossbar end would be placed to the east. At noon the shadow clock would be turned 180°, so that in the afternoon, the crossbar end would be to the west.

In 1965 Bruins[132] explored Borchardt's theory mathematically and concluded that a set of three crossbars of differing heights would mean that the time periods measured by the clock were a very good approximation to seasonal hours.

In this section, the arguments for and against the crossbar hypothesis will be examined carefully. Firstly, we shall examine the written evidence, then the instrument in the context of sundials in ancient Egypt, the argument for the measurement of seasonal hours and finally, the issues raised by the conjectured manner of usage of the crossbar shadow clock.

Textual Sources

The Osireion text E2 (Figure 17) is headed by a diagram which has the figures 3, 6, 9, and 12 labelling the gaps between the hour marks. The diagram is simple, but we gain one very important piece of information from it: that the shape of the device was like our letter 'L'.

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131 Borchardt's diagrams (in *Die Altägyptische Zeitmessung* and 'Altägyptische Sonnenuhren') seem to indicate that he believed the shadow casting edge to be at the same height as the surviving vertical block.
132 Bruins 'The Egyptian Shadow Clock'.

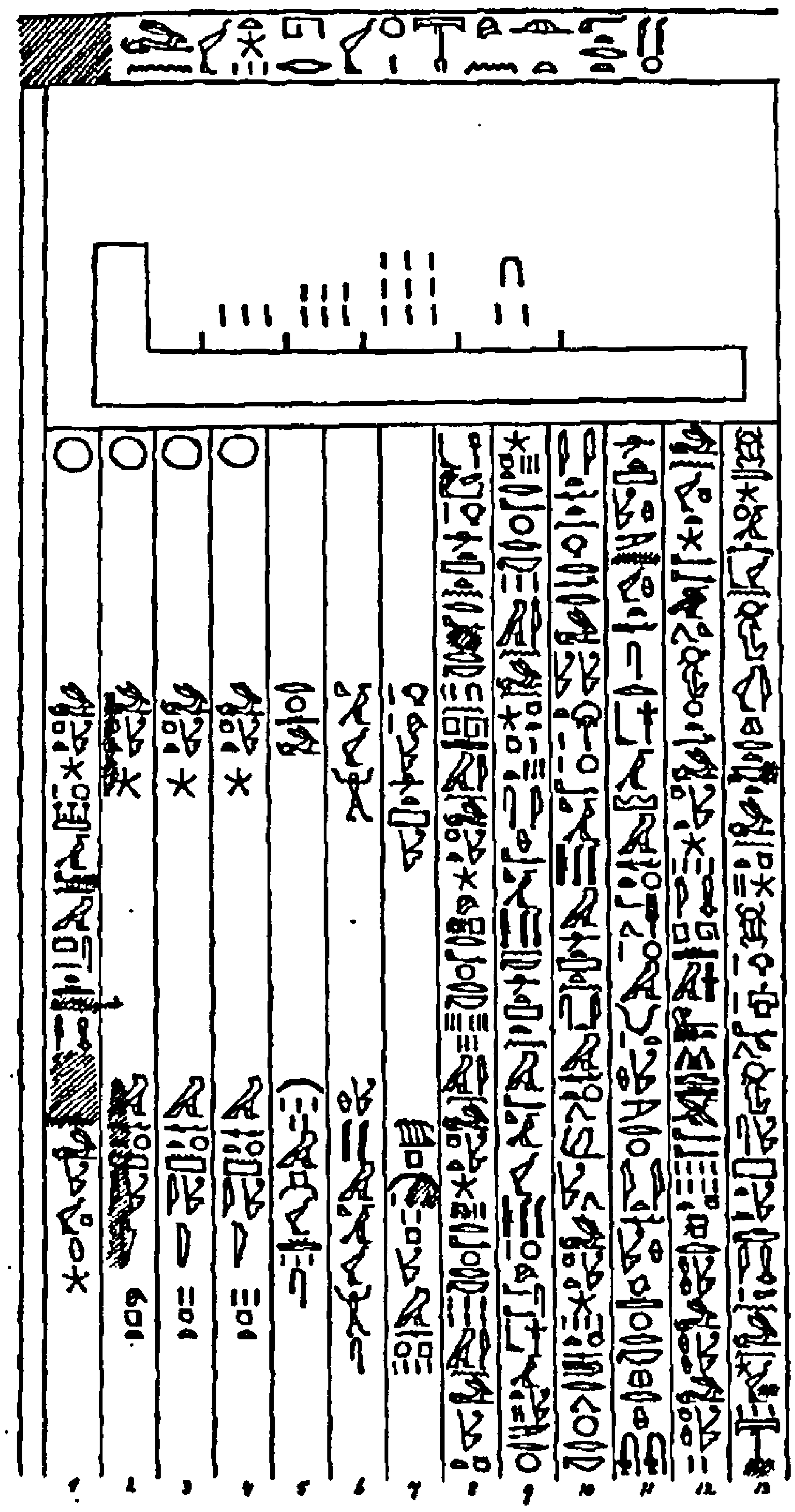

Figure 17: Shadow clock text from the *Book of Nut* in the Osireion
(from Frankfort *The Cenotaph of Seti I*)

The Egyptian artistic style portrays three-dimensional objects by displaying the characteristic shape of the object with other details shown above or around the main outline.[133] The characteristic shape of the shadow clock was obviously felt to be L-shaped, but the scale markings were important and so were depicted above the main component. The addition of a crossbar would clearly make the characteristic shape of the object a 'T'. A diagram of such a clock would probably be drawn as if looking down on the clock, with the hour marks represented on the base rod with no need to distort their position. No such diagram is known to exist.

[133] This is clearly illustrated to be the preferred method even for technical diagrams, such as architectural plan (Carter and Gardiner 'Tomb of Ramesses IV' and Davies 'An Architect's Plan from Thebes' for example).

The text below the diagram is in 13 columns. The manufacture of a shadow clock is first described, followed by instructions for using the instrument. There are gaps of omission in the text. The extract presented below concerns the usage of the clock. The problem of interpreting the text comes from the unusual vocabulary employed.

> If you correctly adjust this *st3t* rightly in the sun alignment,
> its head end in the east which is on this *mrḫyt*,
> then the shadow of the sun will be exactly on this *st3t*.
> Then, with the end of the fourth hour you should turn this *st3t*,
> its *mrtwt* towards the east accompanying the sun standing at the *wpt* of this *mrḫyt*.

The entire instrument is called a *sṯ3t*. The word *mrḫt* or *mrḫyt* has been used elsewhere for 'surveying instrument' in general[134] but the usual form of instrument to which the word refers resembles the unadorned shadow clock in all ways but one: the lack of hour marks on the upper face of the base rod. It seems most likely, therefore, that the word should apply to the L-shaped part rather than to the crossbar. However, in the reworkings of de Buck's translation[135] of this text by Parker,[136] Bruins,[137] and Clagett,[138] the translation of *mrḫyt* as 'crossbar' has become established. The word *wpt* used anatomically means 'top of the head', but also has the meaning of 'zenith'. *Mrtwt* is not understood at all, although Parker uses it to indicate the scale rod of the instrument.

The extract indicates that the instrument needed to be aligned correctly in order to produce a reading. The act of turning the clock can be interpreted in two ways: a single 180° motion at noon[139], or a continuous turning towards the sun.

A much later text[140] E4 dating from the Roman period is a fragmentary papyrus showing a diagram of a shadow clock (Figure 18).

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134 Žába *L'Orientation Astronomique* p. 55, 56 (where he believes that *mrḫt* applies to the vertical block).
135 Frankfort *The Cenotaph of Seti I.*
136 *Egyptian Astronomical Texts* 1 pp. 116-117.
137 Bruins 'The Egyptian Shadow Clock'.
138 Clagett *Calendars, Clocks, and Astronomy* pp. 467-470.
139 Which occurs at the end of the fourth hour in this text, which describes an instrument with just four hour marks instead of the five marks we find on existing shadow clocks.
140 Griffith and Petrie *Two Hieroglyphic Papyri from Tanis*.

The diagram appears to show the base rod of a shadow clock, with numerals 6 and 2 above it. These numbers probably represent the hour indicated when the shadow fell on that portion of the scale. The diagonal lines converge to a point now lost. The altitude of this point above the base line has been thought[141] to indicate a gnomon height greater than the block which survives on E3 thus suggesting the addition of a crossbar. However, the argument is flawed due to the Egyptian style of graphically representing relationships and not proportions (as we noted was the case with the hour marks in the Osireion diagram which were shown almost evenly spaced, retaining their relative position but not their exact position). Thus the nature and dimensions of the gnomon which is now lost from this papyrus can only remain conjectural.

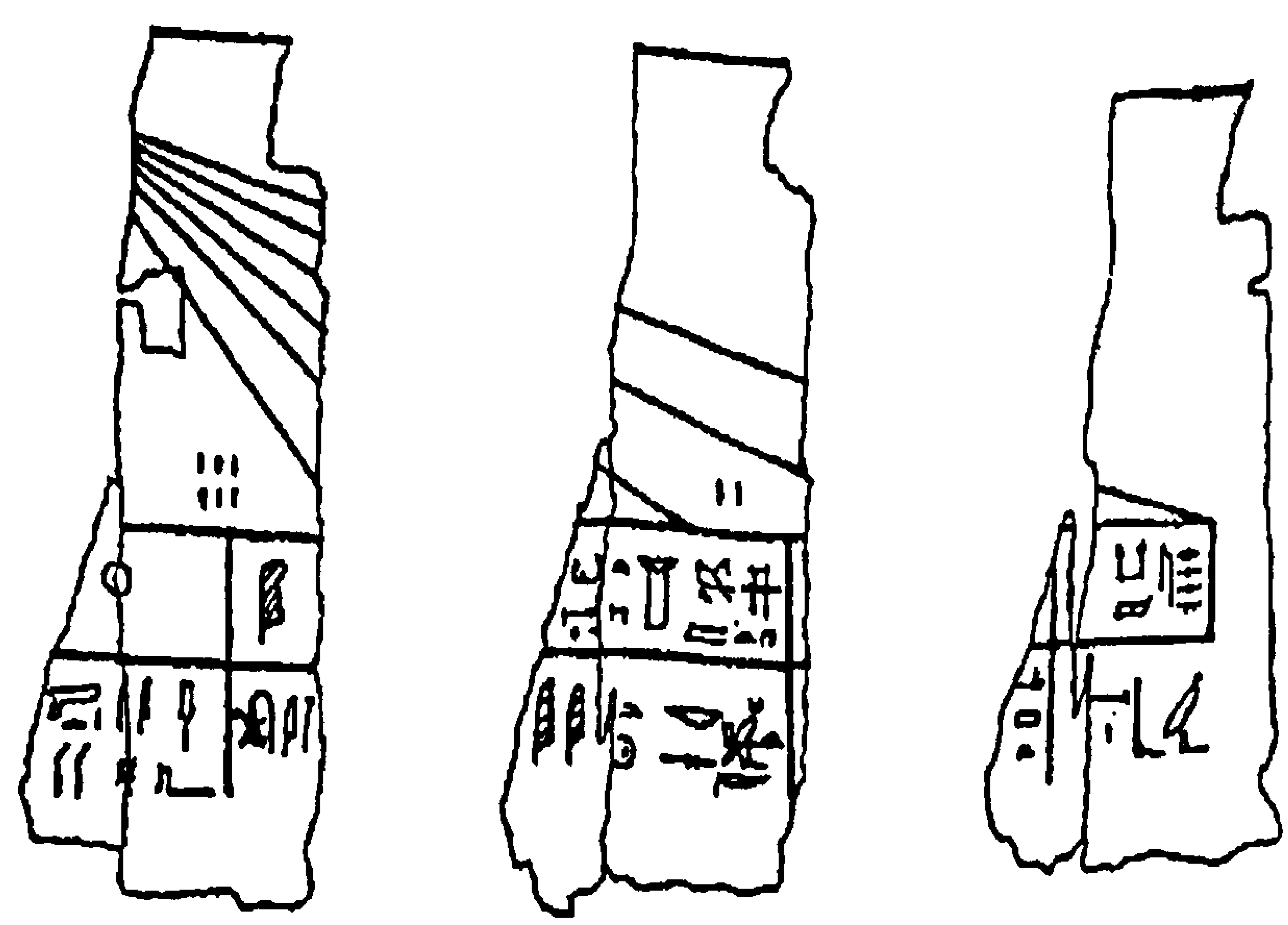

Figure 18: Tanis papyrus
(from Griffith and Petrie *Two Hieroglyphic Papyri*)

The placement of the hour numbers and the convergence of the diagonal lines indicate that this diagram, like the one in the Osireion, shows the instrument from the side. Although the gnomon part is lost, it seems most likely that this diagram, when complete, showed an L-shaped object, not a T-shaped object viewed from above.

[141] Borchardt 'Altägyptische Sonnenuhren'.

These two texts are widely separated in date. The Osireion text shows and mentions only four hour marks whereas the surviving shadow clock E1 which predates the carving of the text has five. It has been argued[142] that the Osireion text dates back to a time when shadow clocks originally had only four marks, and the old text has been included as part of the primaeval style of the Osireion.

The Shadow Clock in the Context of Egyptian Timekeeping

The shadow clock is the earliest formal timekeeping device for finding the hour of the day from Egypt which survives to the present. It is probable that simple gnomons were used before the New Kingdom to mark periods of time during the day for such purposes as workers' shifts, but currently no object has been identified as such an instrument.

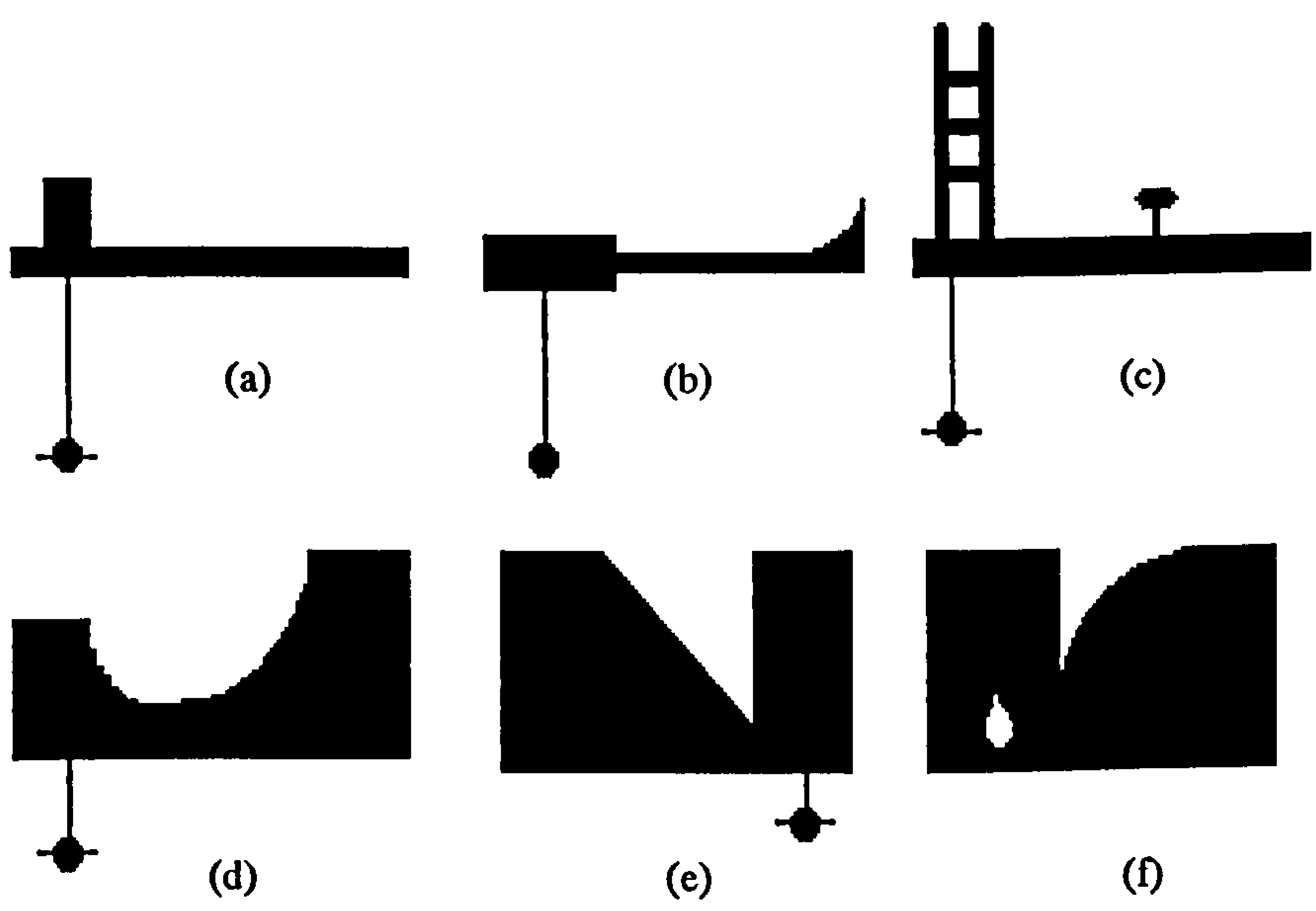

Figure 19: Ptolemaic hieroglyphs depicting shadow clocks and sloping sundials

Hieroglyphs depicting shadow clocks are not common, but several exist from the Ptolemaic era.[143] Two of the Ptolemaic hieroglyphs depict sundial types of which examples have survived: diagram (a) of Figure 19 represents a shadow clock similar to the Berlin

[142] *Egyptian Astronomical Texts* 1 p. 118.
[143] *Valeurs Phonétiques des Signes Hiéroglyphiques d'Époque Gréco-Romaine Vol. 4* p. 731.

instruments, and diagram (e) represents the later type of sloping or Egyptian seasonal sundial, of which several examples survive.

Figure 19 (b) shows a shadow clock with a curved scale. This development may have been made to facilitate the measuring of hours near dawn and sunset and seems to lead to the design of the sundial (d). Figure 19 (c) has two structures attached to the base rod, offering a possible explanation for the pair of holes on the top face of the gnomon block E3. The crossbar appears in no known hieroglyph of a shadow clock.

Without surviving examples, it is difficult to reconstruct precisely the development of the shadow clock. The hieroglyphs suggest an evolving design leading from the shadow clock to the sloping sundial, whereas the two distinct groups of surviving sundials, shadow clocks and sloping sundials, have led researchers to treat the sloping sundial as a separate instrument.

The observation that there is a developmental path from the New Kingdom shadow clock to the later sloping sundial has important repercussions in the discussion of the crossbar hypothesis. As already noted, the crossbar appears in no known hieroglyph representing a timekeeping instrument. Neither Borchardt nor any subsequent researcher has suggested that sloping sundials bore a crossbar. In order for the crossbar hypothesis to stand, three pieces of evidence must fit together in a logical way:

1) New Kingdom crossbar shadow clocks
2) Hieroglyphic representations of sundials
3) Late Period sloping sundials

In past studies, 1) and 3) have been treated as distinct groups, with the crossbar hypothesis affecting only 1), and a separate development postulated for 3). The addition of 2), however, throws this scenario into disorder. The Ptolemaic hieroglyphs show that the shadow clock was subject to certain additions and developments which have not survived in concrete form to the present, but which did not change the fundamental nature of the instrument nor, probably, the manner in which it was used. The hieroglyphs also make plain the close relationship between the shadow clock and the sloping sundial suggesting that the later was a development of the former.

For the crossbar hypothesis to hold with the addition of 2), it must be suggested that a crossbar clock which is used by rigorous east-west alignment and may, Borchardt and Bruins suggest, be seasonally adjusted by raising or lowering the shadow-casting edge of the crossbar, develops into a non-crossbar, sun-pointing instrument which is seasonally adjusted by means of additional hour scales. I suggest that the difference between these two instruments is too great for a logical development path fitting the evidence of the Ptolemaic hieroglyphs to be credible.

Furthermore, it is difficult to see why, if the crossbar clock had from its origin measured the desired time periods, the conservative Egyptians would have continued to adjust the design to suit the timekeeping requirements of the day. It seems far more likely that the original Egyptian device, an L-shaped, sun-pointing, non-seasonal instrument should have been refined over the centuries to cope with the increasing demand for some uniformity of time that would have resulted from foreign input and local progress.

Measurement of Seasonal Hours

It is the habit of the modern mind to ask, when approaching an ancient timekeeping device, 'How accurate is it?'. This is the question underlying many previous studies of all types of Egyptian timekeeping methods. The question presupposes that the researcher knows the nature of the time to be measured by the instrument, and will then gain some understanding of the level of competence of the manufacturers by calculating how well the object performed its task. In such an environment, Borchardt supposed that the shadow clock should measure seasonal hours, and that to make the instrument perform adequately, a crossbar must be added. His arrival at this conclusion is based on the lack of any other measure of hours that would fit with the idea of a formalised timekeeping instrument. In other words, Borchardt started from an idea of 'time' and made the shadow clock measure it to his own satisfaction.

We must examine whether his assumptions are acceptable. Firstly, was the concept of seasonal hours understood and accepted at the time of the origin of the shadow clock? We know that by the reign of Amenhotep I, the difference in night length in winter and summer was known to exist and had been implemented[144] in the form of the seasonal water-clock.

I Akhet	day hours 16	night hours 8	[ ]
II Akhet	day hours 14	night hours 10	Phaophi
III Akhet	day hours 12	night hours 12	Athyr
IIII Akhet	day hours 10	night hours 14	Choiak
I Peret	day hours 8	night [hours] 16	Tybi
II Peret	day hours 6	night hours 1[8]	Mekhir
[III] Peret	day hours 8	night hours 1[6]	Phamenoth
[IIII P]eret	day hours [10	night hours 14]	Pharmuthi
[I Shem]u	day [hours] 12	[night hours 12]	Pakhons
II Shemu	day hours 12	night hours [ ]	Payni
III Shemu	day hours 16	night hours 8	Epiphi
IIII Shemu	day [hours] 18	night hours 6	Wep-Renpet

Table 42: Comparison of day and night lengths through the year from the Cairo calendar

During the XVIIIth dynasty, a list of day and night lengths was composed[145] (Table 42)[146] based on some unspecified unit. In III Akhet, the night and day were of equal length: 12 units. This suggests that the equinoxes occurred in III Akhet and I Shemu, with the summer solstice in IIII Shemu and the winter solstice in II Peret. Clagett places the discussion of this list in a section entitled 'Traces of a 24-hour day with Equal Hours' but states that 'any modern

[144] Water-clock text from the tomb of Amenemhet (see Borchardt *Die Altägyptische Zeitmessung* and Clagett *Calendars, Clocks, and Astronomy* pp. 457-462).
[145] Cairo Papyrus 86637, Bakir *The Cairo Calendar.*
[146] After Clagett *Calendars, Clocks, and Astronomy* Fig III.58a,b.

assumption that they used accurate equinoctial hours from month to month over the whole year ... [is] exceedingly unlikely'.

Neugebauer and Parker, having discussed the probable nature of decanal time and produced formulae for night length based on decanal hours show that from their model, the twelve decanal hours of the shortest night span six modern hours.[147] This observation implies that the units used in this table are modern 60-minute hours, and also that night length was based on the visibility of decans, while day length was simply '24 - length of visibility of decans'. This definition of 'day' is very unusual indeed and is hard to accept against the background of New Kingdom thought.[148] In the New Kingdom, we find that religious texts treat the hours around dawn and sunset very differently from the hours clearly part of the day and part of the night. It is possible that although the day had twelve hours, and the night had twelve hours, the transition between day and night and vice versa was not instantaneous. That is, there were two periods of time, dawn and sunset, when time was not quantifiable. As Neugebauer and Parker noted, decanal hours would have been of varying length, but were certainly consistently shorter than 60 minutes. Suppose that the author of this list had found some means to reproduce one decanal hour (for example, a vessel resembling a small water-clock that emptied in a given time), and that he had some definition (perhaps simply his own perception) of when day began and ended, and when night began and ended. We find that, for example, if the unit had been 45 minutes, a period of 3 modern hours around dawn would occur between 'the end of the night' and 'the beginning of the day' with a similar period around sunset. To a certain extent, a shorter unit and time around dawn and sunset which is

[147] *Egyptian Astronomical Texts* I p. 119 Shortest night occurs when the sun is in ♋ 10°, where the time from sunset to sunrise is 10 hours. To find the length of the twelve decanal hours, we must subtract β_8, β_9, β_{10}, β_{29}, β_{30}, and β_{31} ($238^m\ 56^s$) from 10 hours leaving $6^h\ 1^m\ 04^s$.

[148] See Part II.

not incorporated into the measuring scheme could explain the large ratio between the length of night and day on the shortest and longest days. However, the most likely explanation of the data within the table is that the pattern which occurred near the equinoxes, that is the time of the greatest rate of change of day length, was simply extended to its conclusion leading to the length ratio of 3:1 at the solstices.

Returning to the connection between the shadow clock and the seasonal hour, we still have no firm evidence that the seasonal hour was the timekeeping goal of the shadow clock. Instead, it would be much more relevant to ask whether the shadow clock supports or rejects the theory that some sort of system of equal hours existed and was used in the early New Kingdom.

To answer this question, we must examine the shadow clock in its unadorned, L-shaped configuration, and also analyse the effect of the crossbar and east-west alignment, in order to assess whether we can learn anything about the nature of Egyptian day hours in the New Kingdom, and whether the crossbar is indeed a necessary, logical and probable addition to the shadow clock.

Bruins evaluated shadow lengths at the solstices and equinoxes at a latitude of 30°N for a crossbar clock placed east-west. In his concluding remarks, he implies that the marks on the existing shadow clocks when used in conjunction with crossbars of varying heights produced seasonal hours with great accuracy. In fact, the accuracy to which he refers is not relating the seasonal hour shadow lengths to the extant markings, but is actually referring to the fact that the ratios between shadow lengths at seasonal hours remain very similar throughout the year. This observation has no bearing on the 'accuracy' of the shadow clock, and merely implies that a seasonal hour sundial made in the fashion of the hypothetical crossbar clock would need only interchangeable crossbars, and no adjustment of hour marks. The relationship between the 1:2:3:4:5 marking ratio and seasonal hours is not as strong as Bruins and Borchardt initially suggest.

At a latitude of 30°N, to follow Bruins' own work, we need to find the position of the sun at each seasonal hour through the year to gauge Borchardt's assertion that the crossbar shadow clock measured seasonal hours. To simplify matters, Bruins considered the sun at the equinoxes and solstices only.

We need to find the declination of the sun at the solstices, for which we need to know the obliquity of the ecliptic, ε, for the epoch in question. The formula[149] for ε is

$$\varepsilon = 23°26'21''.448 - 46''.8150\,T - 0''.0059\,T^2 + 0''.001813\,T^3$$

where T is the number of Julian centuries after J2000.0. We can use T = -35 to produce an approximation[150] for ε in 1500 BC: 23.9°.

To find the hour angle of the sun at each seasonal hour between sunrise and sunset, we first find the hour angle of the sun at sunrise (HA_r)

$$\cos HA_r = -\tan\phi \tan\delta$$

where ϕ is the latitude and δ the declination of the sun ($\delta = 0$ at the equinoxes, ε at the summer solstice and $-\varepsilon$ at the winter solstice). We then divide HA_r by six to obtain the angular increase per seasonal hour for any declination of the sun. To find the altitude and azimuth of the sun for each seasonal hour, we have two equations:

$$\sin alt_i = \sin\phi \sin\delta + \cos\phi \cos\delta \cos HA_i$$

$$\cos az_i = \frac{\sin\delta - \sin\phi \sin alt_i}{\cos\phi \cos alt_i} - 90°$$

where i = 0 to 12, and HA_i indicates the hour angle of the sun at the beginning of the first

[149] Taff *Computational Spherical Astronomy* p. 52.

[150] The formula is increasingly inaccurate as $|T|$ becomes large, but is good enough for the present context. Bruins apparently did not correct for the obliquity of the ecliptic, but the difference in results is in fact negligible, and has no impact on the conclusions drawn in this study.

hour, the end of the first hour, the end of the second hour .... up to the end of the twelfth hour of the day.

If we now consider the model of a crossbar clock aligned east-west, we can now calculate the shadow lengths for any height of crossbar. Bruins wanted to compare his results with the Osireion ratio. The marks were spaced at 30, 18, 9, and 3 units from the gnomon. Bruins therefore scaled his results so that the shadow length at the beginning of the second seasonal hour was thirty units. The results of our calculations, which agree closely with Bruins' own figures, are shown in bold type in Table 43. Bruins discounted the fifth mark present on the extant shadow clocks and has scaled the results so that the fourth mark was correct. This left only three marks to be compared. From the table, it is clear that although the third mark (18 units from the gnomon in the Osireion diagram) is in an acceptable position, the first and second marks clearly do not indicate seasonal hours with any degree of accuracy at all. The percentage errors shown in the table are unacceptably high for the first mark especially, and for the fifth mark which we also include here.

It must be remembered that the crossbar was added to produced an 'accurate' clock. No such 'accuracy' is to be found here.

Markings on shadow clock (length from gnomon to mark)					
Osireion Diagram	**3.00**	**9.00**	**18.00**	**30.00**	**[45.00]**
Seasonal hour shadow lengths					
Winter Solstice	**4.54**	**9.82**	**17.13**	**30.00**	**65.71**
% error against Osireion	33.92%	8.35%	-5.08%	0.00%	31.52%
Equinoxes	**4.64**	**10.00**	**17.32**	**30.00**	**64.64**
% error against Osireion	35.34%	10.00%	-3.93%	0.00%	30.38%
Summer Solstice	**4.76**	**10.20**	**17.54**	**30.00**	**63.38**
% error against Osireion	36.97%	11.76%	-2.62%	0.00%	29.00%

Table 43: Comparison of existing hour marks with those required to produce seasonal hours

Usage of the Shadow Clock

The manner of usage of a clock with a crossbar would require an accurate east-west alignment. A cardinal alignment is not a simple undertaking and certainly could not be produced by the clock instantaneously. This implies that an external reference must be available for the instrument to be used. Moreover, the crossbar clock would also have to be aligned correctly in the other two axes of rotation in order to achieve any consistency and accuracy in use. Provision for adjustment in rotation about the axis parallel to the crossbar is made by the accepted addition of a plumb bob and a reference line, but no method of reference for the third axis of rotation (along the length of the base rod) is either evident or proposed by Borchardt or by Bruins. This third axis of rotation is equally as important as the other two for the accuracy of the crossbar clock, for if the shadow-casting edge of the crossbar is inclined, this affects directly the length of shadow thrown onto the base rod, especially for the hours around midday.

We see that the crossbar clock is by nature a stationary instrument, and would have to be set up on a datum line and turned at noon, to be consulted *in situ* at any time. A datum line could account for accuracy in all three axes (such a datum might be provided by a slot in a stone, for example) but in this case it is unclear why a plumb bob would be necessary. If the datum only provided an east-west reference (using, for example, a reference point on the horizon) the instrument would need not only the plumb line but also stability along the axis of the base rod, which is not provided by the long crossbar placed on top of the existing gnomon block.

The pattern of usage of the crossbar clock is inconsistent with the well-attested plumb bob attachment and the size of the surviving instruments.

In contrast to the idea of a stationary instrument, the small size of the surviving instruments and the dimensions which appear in the Osireion text describing the shadow clock suggest strongly that the instrument was intended to be portable.[151] This is also borne out by the provision of a hole for attaching a plumb bob cord in the gnomon block E3, and also by the hieroglyphs in Figure 19 which show plumb bobs suspended from the all the clocks and sundials. The plumb bob suggests that the instrument needed to be levelled by the observer quickly, easily, and often.

The evidence presented above, from consideration of written evidence, the place of the device in Egyptian timekeeping, accuracy and usage, seems to weigh against the crossbar hypothesis. This is in addition to the fact that no physical evidence for the crossbar survives except for the holes in the top of the vertical blocks, for which, as we have seen, other explanations exist.

Until further information about this instrument is discovered, it seems that the simplest, most obvious and most easily supported theory is that the shadow clock is an L-shaped, portable, personal instrument which marks certain time periods at any location. Alignment is provided by levelling the instrument using the plumb bob and by pointing the device towards the sun.[152] The correct alignment will be indicated by the shadow of the gnomon block falling exactly on the scale, and slight rotation around the axis of the base rod does not affect the function of the instrument. This as described in the Osireion text passage in Figure 17

"then the shadow of the sun will be aligned on this *sṯȝt*".

The simple ratios between the markings on the scale suggest a convenient 'rule' for making a clock, rather than an accurate measure for seasonal hours.[153]

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[151] Macnaughton 'The use of the shadow clock of Seti I', Isler 'The gnomon in Egyptian antiquity' and Žába *L'Orientation Astronomique* discount the crossbar but present only short arguments.

[152] A description of the method is given in Isler 'The gnomon in Egyptian antiquity'.

[153] Fermor ('Timing the sun in Egypt and Mesopotamia') agrees that looking for 'accuracy' in shadow clocks is futile but concerning why the hour marks are in the ratio 1:2:3:4:5 says 'it is not necessary to ask how the

With no attachments but the plumb bob, the markings on the scale do not measure seasonal hours. Although seasonally-adjusted hours during the night were being measured by water-clocks during the New Kingdom, we cannot confirm that the day hours and the night hours were perceived as being of the same nature. The time periods around dawn and sunset were clearly considered to be transitional periods and seem not to have been divided formally in New Kingdom times. The shadow clock was possibly the only timekeeping instrument extant during the New Kingdom to have secular as well as sacred applications, so it is possible that the time defined by the shadow clock was used for other purposes than that defined by star clocks and water-clocks. Finally, the concept of standardisation of time was probably not a recognised goal for timekeeping devices in the New Kingdom.

The hypothesis of the crossbar is therefore inconsistent with what is now known about Egyptian timekeeping.

Timekeeping Properties of Sun-aligned Instruments

The L-shaped shadow clock, in contrast to the crossbar clock, does not measure time periods that are related to the 'hours' of the present time or of classical antiquity. It is easy to find the lengths of these time periods. We need to know the latitude at which the observations took place, the height of the gnomon and the position of the hour marks relative to the gnomon.

For the later instrument from the Berlin Museum,[154] we find that the gnomon height, g, is 28 mm, the distance L_1 from the vertical block to the centre of the furthest mark is 191 mm, from the vertical block to the next mark L_2 = 127 mm, L_3 = 76 mm, L_4 = 39 mm, and L_5 is

---

Egyptians came by the correct timings to which they then found a close mathematical expression, since their timings are not correct. Perhaps the formula is not empirically based but stems from some false conception of celestial geometry and the path of the sun.'

[154] Dimensions are taken from the replica in the Science Museum, London.

13 mm.

The altitude of the sun for each hour mark is given by

$$\tan alt_i = \frac{g}{L_i}$$

where i = 1...5. From this, with the latitude of the observer, ϕ, and the declination of the sun, δ, we can find the hour angle of the sun, H_i, and hence the time interval between the shadow crossing successive marks.

$$\cos H_i = \frac{\sin alt_i - \sin \delta \sin \phi}{\cos \delta \cos \phi}$$

This analysis, using E3, raises three issues about the sun-pointing shadow clock theory. Firstly, we find that for latitudes within New Kingdom Egypt, the mark nearest the vertical block will not be reached by the shadow of the sun for more than half the year because the sun does not attain a high enough altitude. While considering the implications of this finding, it must be noted that this behaviour may not have been exhibited by all shadow clocks. The surviving examples are few, but the time difference between, for example, the two Berlin instruments indicates that the surviving shadow clocks represent only a small sample of the occurrence of this type of timekeeping method. It is likely that practical, working examples were unadorned, wooden objects which would not have been preserved. We therefore cannot state with certainty that the Berlin instruments were made with the same precision as working examples. We must also bear in mind that although we have textual evidence for the 1:2:3:4:5 ratio between the hour marks, the portion of E2 which might have given us the 'rule' for gnomon height is missing, resulting in the current discussion of gnomon shape and usage.

It is, however, easy to find the results of the equations above for a variety of gnomon heights, and gain some insight into the nature of the time periods that the L-shaped shadow clock would produce. The results for E3 are shown in Figure 20.

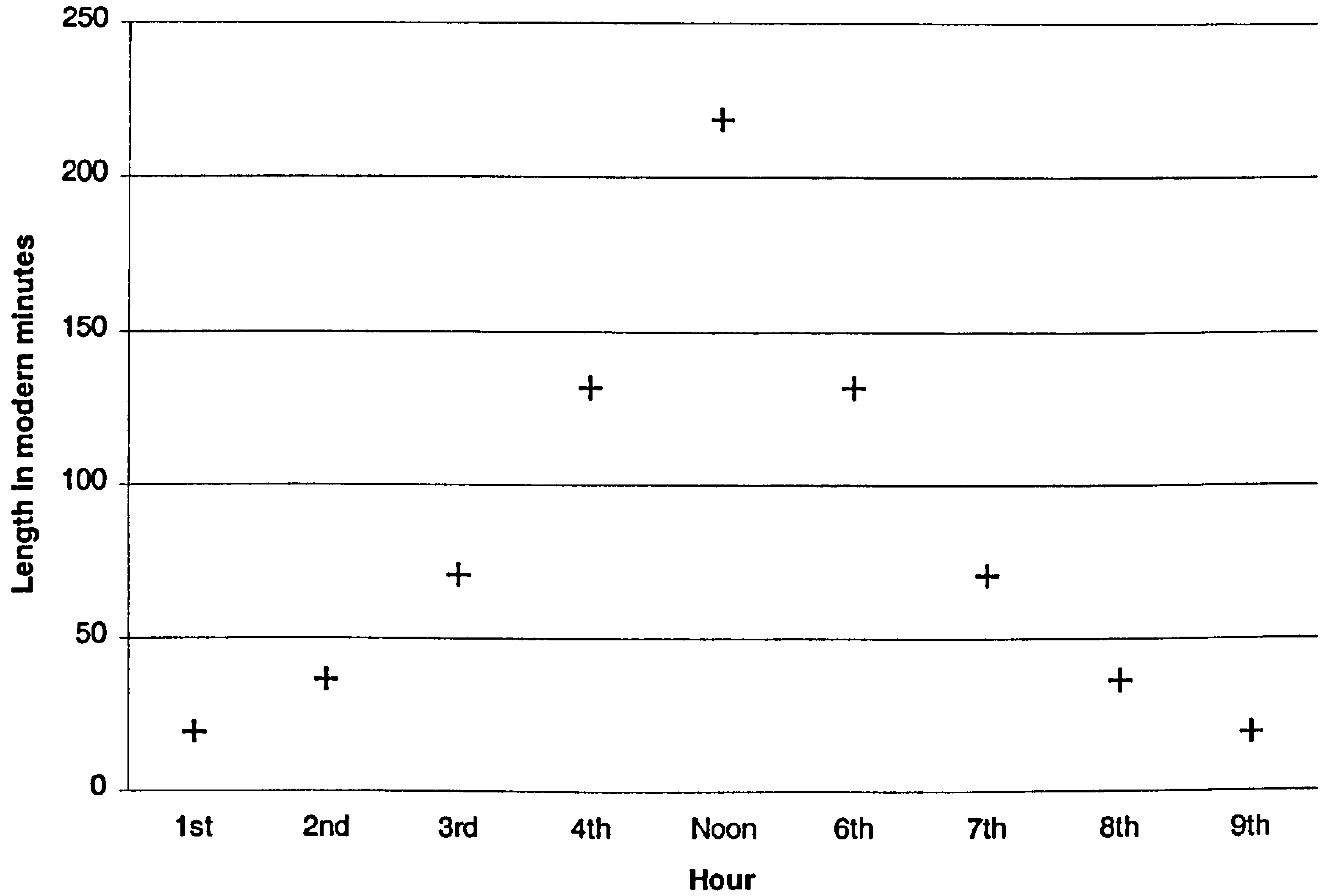

Figure 20: Time periods measured by a sun-aligned shadow clock on the summer solstice at Luxor

The second issue raised in this analysis is the question of what happens around noon. The crossbar clock threw no shadow at noon, and marked 10 time periods (for a shadow clock with five hour marks) the first time period ranged from the crossing of the furthest mark by the shadow in the morning until the shadow crossed the next mark, and so on to the fifth period when the shadow moved from the closest mark towards the vertical block until it disappeared at noon. The five hours of the afternoon followed the same pattern after reversing the instrument. This system does not hold for the sun-pointing shadow clock, for only on (presumably) two days of the year will the sun's shadow reach the mark nearest the gnomon at precisely noon. On those days, a clock with five marks would define nine points in time: the end of the first period (dawn up to the time when the shadow crossed the mark furthest from the gnomon), end of the second period, ... end of the fifth period (noon), ...

end of the ninth period / beginning of the tenth period.

On days closer to the summer solstice than these special days, there would be an additional period of time marked by the passage of the shadow from the mark nearest the gnomon towards the gnomon, turning at noon and returning to this closest mark. On these days, eleven regions of time would be defined.

On days closer to the winter solstice, as we have already remarked, the noon shadow would not reach the mark closest to the gnomon. The remaining marks would define nine regions of time.

The third issue concerns the lack of uniformity in the length of the time periods defined by the instrument. It has already been noted that the time periods around midday presented a problem. Moving through the year, the hours around midday would be long while the midday hour itself, if it existed, would range from negligibly short to very long.

From a modern standpoint, these three issues combine to make the sun-pointing shadow clock a very crude timekeeping instrument. Although simple to make and use, the instrument produces no regular 'hours' and seems to be limited to use in late spring to early autumn only. In contrast, the crossbar clock produces, if not seasonal hours, then at least a more regular count of the passing of time, and eliminates the problem of noon hours entirely. It is easy to see why the crossbar clock has become accepted. It represents the Egyptian shadow clock as it *should* have been made and used. Even though the evidence presented before this analysis of hour lengths indicated strongly that there was no crossbar, nor an east-west orientation, the points raised above make the alternative, the sun-pointing L-shaped shadow clock, seem very unattractive.

One final argument must be added that may suffice to explain why irregular time periods are actually an indication that the sun-pointing shadow clock theory is more acceptable than the crossbar hypothesis. The sloping sundial is known to exist from the Late Period onwards. We have already mentioned this timekeeping instrument in connection with hieroglyphs of shadow clocks, and have noted that the hieroglyphs provide circumstantial evidence that the sloping sundial was the direct descendant of the L-shaped shadow clock, evolving from it by a series of steps involving the reshaping of the surface on which the shadow falls.

The sloping sundial has survived in greater numbers due to the use of the device as an offering. We have, therefore, sufficient examples for there to be no question that this device had no crossbar and was used by alignment with the sun with the help of a plumb bob, exactly the same manner of usage as the sun-pointing shadow clock. It is also uniformly agreed that the sloping sundial was seasonally adjusted by using seven different hour scales labelled with month names. An example of this type of instrument was found at Qantara[155] and is illustrated in Figure 21.

Other examples of sloping sundials share the same overall composition, but differ in details such as the angle of slope, height of gnomon, and presentation of hour marks. A sloping sundial from the Petrie museum has slanting lines[156] rather than dots (Figure 22).

The survival of the L-shaped shadow clock into the era of sloping sundials is attested by the fragmentary Tanis papyrus, and the Ptolemaic hieroglyphs indicate that more variants of both types of sundial existed than those which have survived to the present. We can analyse the surviving sloping sundials in the same manner as we did the shadow clocks, we have only to correct for the slope of the hour scales. Again, we must allow for the fact that surviving examples may only be representations of working clocks.

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[155] See Clédat 'Notes sur l'isthme de Suez' and Kuentz 'Note sur un gnomon portatif gréco-égyptien'.

[156] A feature it shares with a sloping sundial in the Metropolitan Museum of Art (Scott 'An Egyptian Sundial'). Scott's article lists five sloping sundials or parts of such sundials: the MMA, Petrie, and Qantara examples as well as a gnomon in Turin and a sundial lacking a gnomon originally from the Hoffman Collection in Paris resembling the Qantara sundial except that it has hour dots between lines instead of on them. (See also Petrie *Ancient weights and measures* pp. 45-46, pls. XXV-XXVI and Borchardt *Die altägyptische Zeitmessung*.)

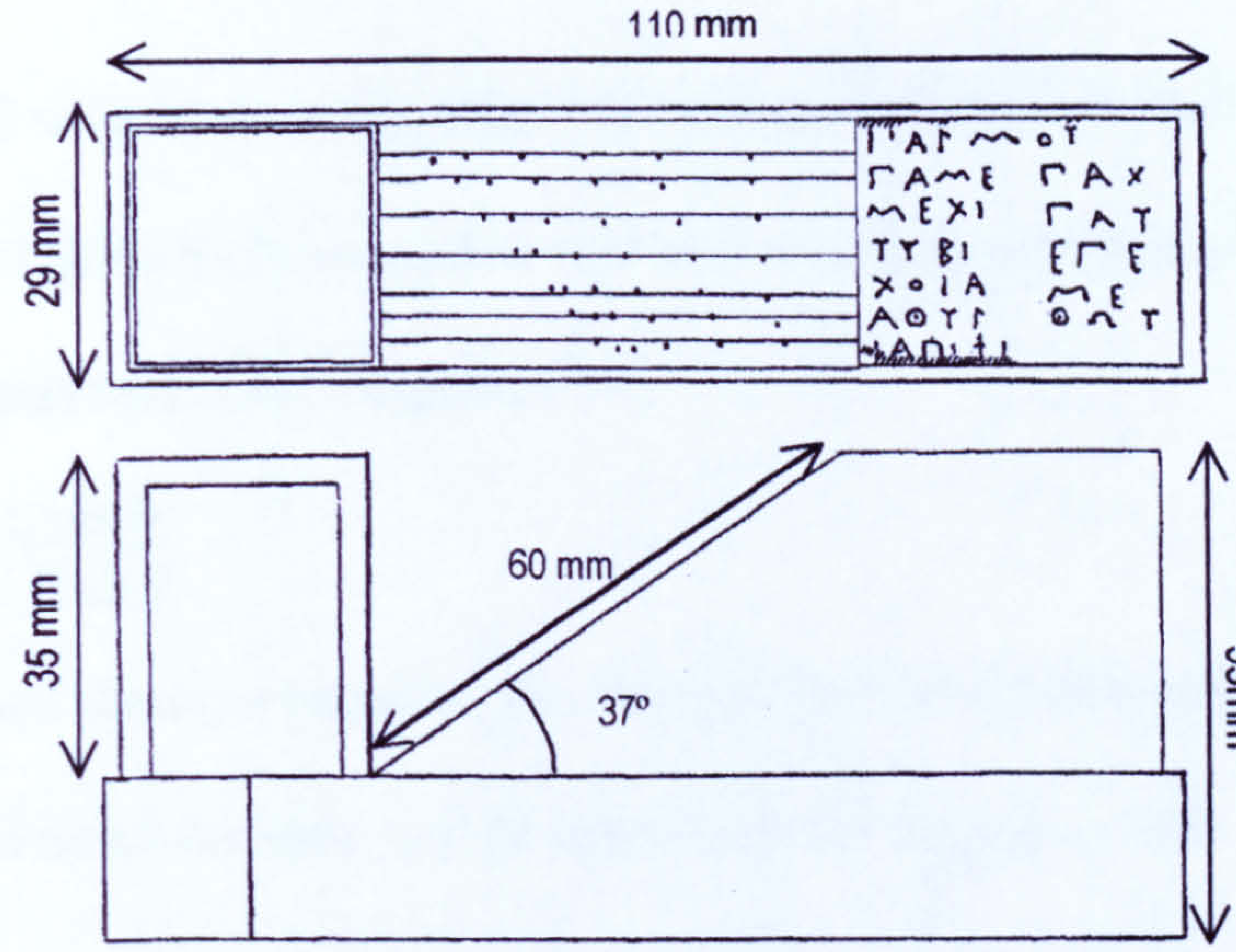

Figure 21: Sloping sundial from Qantara

Figure 22: Two views of the sloping sundial in the Petrie Museum

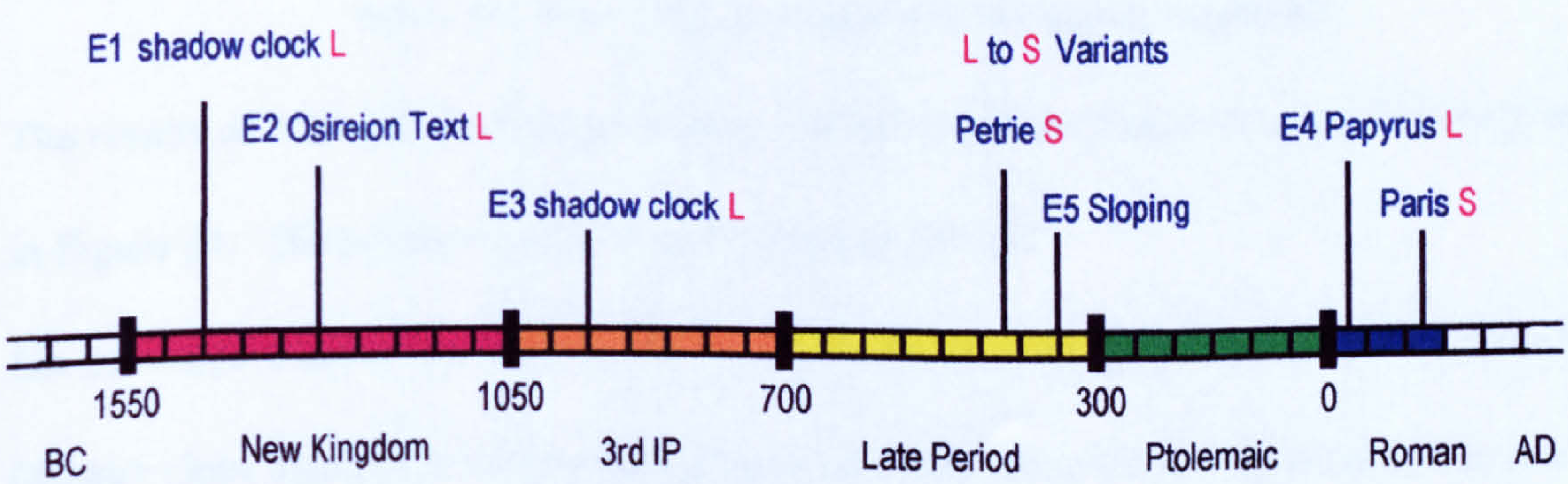

Figure 23: Schematic chronology of Egyptian sundials. 'L' indicates a source relating to L-shaped shadow clocks, 'S' indicates a source relating to sloping sundials

If the angle of slope of the hour scale is θ, and the lengths from the base of the gnomon to the hour marks along the hour scale are l_i then the corresponding shadow lengths L_i projected onto a horizontal hour scale are given by

$$L_i = \frac{g\, l_i \cos\theta}{g - l_i \sin\theta}$$

We can then use the same equations as before to find the altitude and hour angle of the sun at each mark and hence the time periods marked by the sloping sundial.

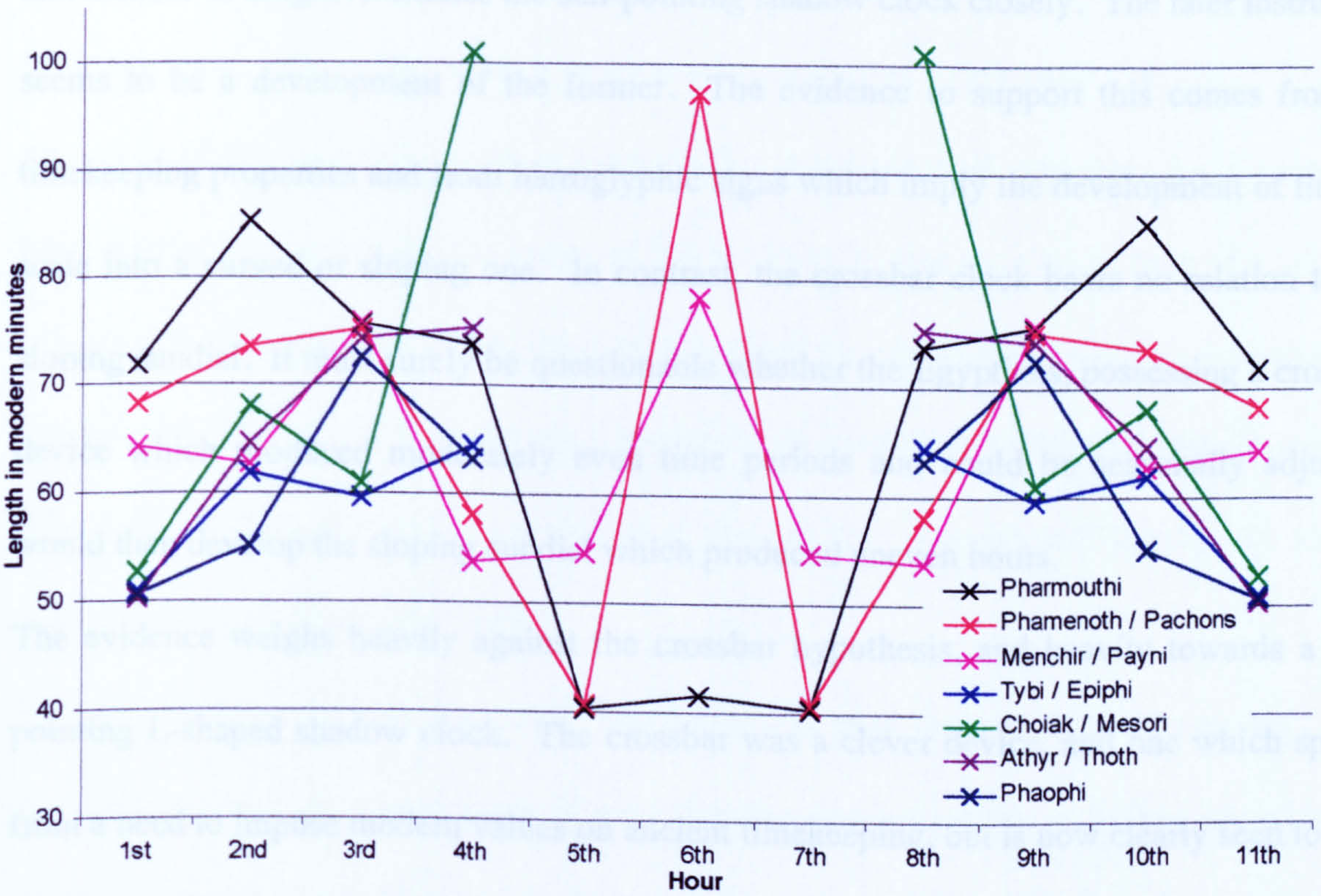

Figure 24: Hour Lengths produced by the sloping sundial E5

The results of this analysis for the sloping sundial found at Qantara (Figure 21) are presented in Figure 24. The latitude used is that of Qantara, 30° 52'.

Let us compare these results with our analysis of L-shaped shadow clocks. We find that the Qantara clock also has trouble with the time around midday for the majority of the year. The same problem occurs with the length of the noon hour, and overall, we see no great uniformity in hour length, although for the early and late hours in the day, the variation in length is not too great.

We find that the characteristics of the sun-pointing L-shaped shadow clock are imitated in the sloping shadow clock. Some refinements have been added, such as the seasonal adjustments and the reducing of the size of instrument needed: the surviving sloping sundials are all small (around 120 mm in length), yet the 'problems' of the earlier instrument that we identified previously are all still in evidence.

To conclude, the timekeeping behaviour of the sloping sundial, with its uncontested form and manner of usage, resembles the sun-pointing shadow clock closely. The later instrument seems to be a development of the former. The evidence to support this comes from its timekeeping properties and from hieroglyphic signs which imply the development of the flat scale into a curved or sloping one. In contrast, the crossbar clock bears no relation to the sloping sundial. It must surely be questionable whether the Egyptians, possessing a crossbar device which produced moderately even time periods and could be seasonally adjusted, would then develop the sloping sundial which produced uneven hours.

The evidence weighs heavily against the crossbar hypothesis, and heavily towards a sun-pointing L-shaped shadow clock. The crossbar was a clever device, and one which sprang from a need to impose modern values on ancient timekeeping, but is now clearly seen to be a fiction.

PART II: COSMOGRAPHY

Egyptian religion contained a strong celestial component at each stage of its development. Religious literature shows us what aspects of the physical and spiritual world particularly interested the priesthood at different times during history. The earliest preserved texts, the *Pyramid Texts,* describe a stellar religion during the Old Kingdom and before, while solar aspects predominated during the later course of Egyptian civilisation. The existence of the lunar calendar[157] shows that interest in the moon occurred at a very early date.

Any study of Egyptian religion must touch on this celestial aspect, and many have done so at great length. It is not within the scope of this study to look at each occurrence of a celestial reference in each religious text of the New Kingdom and to comment on such matters as the relationship of the pharaoh to the sun, creation myths and other topics that include celestial references. Instead, this study concentrates on the practical perception of the sky, the subject that we label 'naked eye astronomy'.

We have already seen how naked eye astronomy was used for timekeeping purposes. This quantitative result of observation is easy for the modern mind to accept as scientific astronomy, yet the context in which the star clocks appear makes it clear that the Egyptians themselves perceived no distinction between 'scientific astronomy' and religion. For this reason, the boundary between astronomy and religion has been drawn, in modern times, between the *method* of timekeeping (the star clocks) and the *purpose* of timekeeping, and between the *physical* aspects of celestial objects (their appearance and their movements, for example) and their *spiritual* meaning to the Egyptians.

However, this distinction has caused a problem. The religion has been studied as a dead and

[157] Parker *Calendars*.

to some extent lost perception of a spiritual world. Understanding of this world is easiest when the subject is considered to be abstract. This is the approach that most studies of the religion have chosen.[158] The problem with this approach occurs when an area is found that has extant references, as is the case with celestial objects. For example, the sun still looks and behaves as it did in the New Kingdom, the stars still appear as points of light, the year still contains events such as the heliacal rising of stars. These things have not changed, neither has the physical perception of these events by humans. What has changed is the spiritual perception, the understanding, the significance of such events.

It is the intention in this section to discuss how naked eye astronomy was incorporated into the Egyptian religion. To do this, the modern boundary between the scientific and the religious will be moved or blurred somewhat. The task of distinguishing which material should be included in this section is aided by the existence of clear stylistic and linguistic differences between texts which deal with celestial objects as physical entities with spiritual components and texts which mention spiritual objects with celestial origins.

The existence of a distinction between the two categories is a function of the Egyptian habit of spiritualising concepts and then using the name of an assigned deity interchangeably with the name of the object itself. The chain of connections between deities, their different aspects, their functions and objects, concepts and events associated with them can often be too complex for the modern researcher, without the benefit of an Egyptian set of contexts and thought processes, to follow, to understand, or to fill in missing parts.

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[158] Only recently has work in the field of Egyptian religion begun to acknowledge that the religion need not be considered to be abstract but can be accepted as a natural human vision of the world. In *Daily Life of the Egyptian Gods*, Meeks and Favard-Meeks present Egyptian religion in a refreshing and sympathetic manner. The religion is treated with the same respect and acceptance that a current major religion would merit. As such, notions such as logic, truth, and consistency are relegated to irrelevance. The world picture is presented as a valid spiritual reality. The book presents not only a study of the religion, but also an approach to Egyptian thought that is worthy of consideration for all aspects of Egyptology.

Where a celestial object is concerned, the researcher must be prepared to combine the physical properties of that object with the spiritual function described by the texts. This has often proved difficult, and in general, astronomical aspects have been neglected.

In this section, a study of the impact of naked eye astronomy on religion in the New Kingdom will be attempted. A new translation of a major astronomical religious text will be presented and discussed, as will astronomical references in other New Kingdom texts. Celestial diagrams which graphically portray the Egyptian view of the heavens will also be discussed, together with their relationship to timekeeping and the information they contain concerning the perception of the sky.

Section F: The Book of Nut

Introduction

The most important single source for astronomical mythology is contained in a series of texts known as the *Book of Nut*. The texts have survived in four sources, all incomplete, two from the New Kingdom and two from around the second century AD.

The *Book* contains three sections: a diagram with texts which we shall refer to as the *Nut vignette*, some text and a diagram dealing with hours and the shadow clock, and a piece of continuous prose called the *dramatic text*.

The portion of the *Book* dealing with the shadow clock has already been discussed at some length in an earlier section (Part I Section E), leaving the Nut vignette and the dramatic text to be discussed here.

Sources

F1 Osireion[159]

In relief on the pitched ceiling of the Osireion, or Cenotaph of Seti I at Abydos. The ceiling contains the Nut vignette (Figure 25), shadow clock texts (Figure 17) and the dramatic text (Figure 28) which appears already corrupted in its latter part.

F2 Ramesses IV[160]

Only the Nut vignette (Figure 27) is used, with some texts missing.

F3 Carlsberg 1[161]

The Nut vignette and shadow clock texts are missing. The papyrus is written in the form of a line by line commentary to the texts within the Nut vignette and the first part of the dramatic text.

F4 Carlsberg 1a[162]

A fragmentary papyrus containing material similar to F3, and presumed to have been written by the same scribe.[163]

159 *Egyptian Astronomical Texts* 1, Chapter II, Frankfort *The Cenotaph of Seti I*, and Murray *The Osireion at Abydos*.

160 *Egyptian Astronomical Texts* 1, Chapter II.

161 Lange and Neugebauer 'Papyrus Carlsberg no.1' and *Egyptian Astronomical Texts* 1, Chapter II.

162 Lange and Neugebauer 'Papyrus Carlsberg no.1' and *Egyptian Astronomical Texts* 1, Chapter II.

163 *Egyptian Astronomical Texts* 1 p. 37.

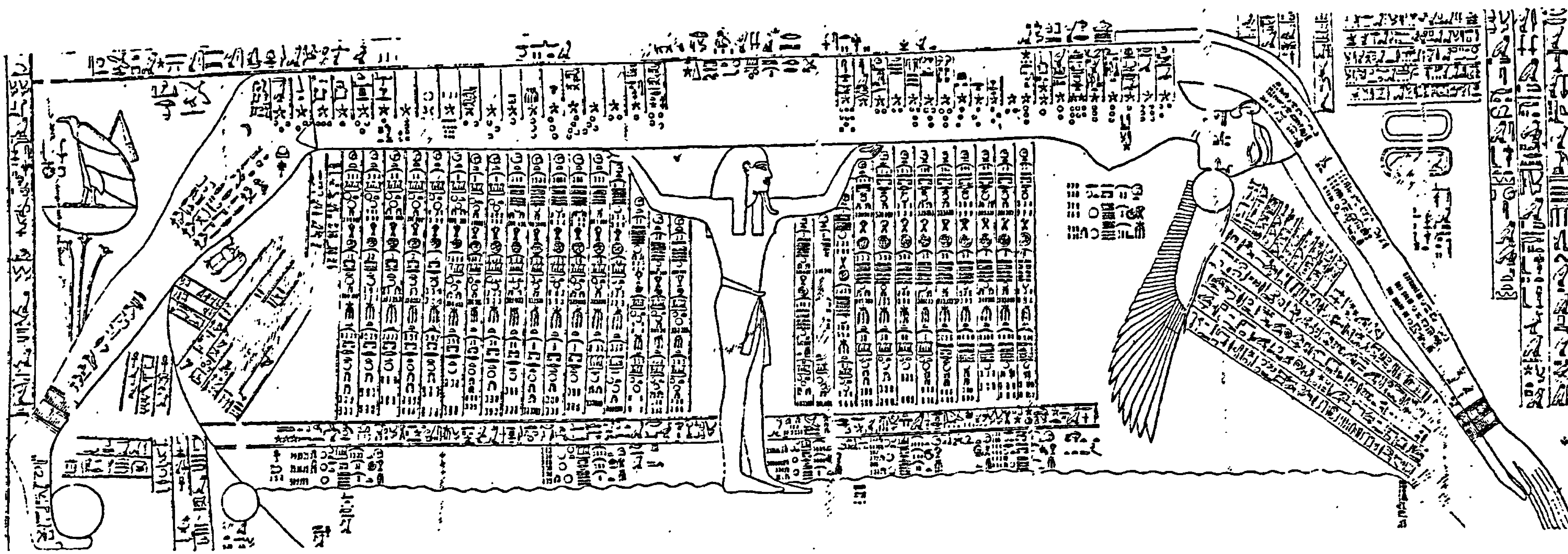

Figure 25: Vignette from the *Book of Nut* in the Osireion

(Emery's line drawing published in Frankfort *The Cenotaph of Seti I*)

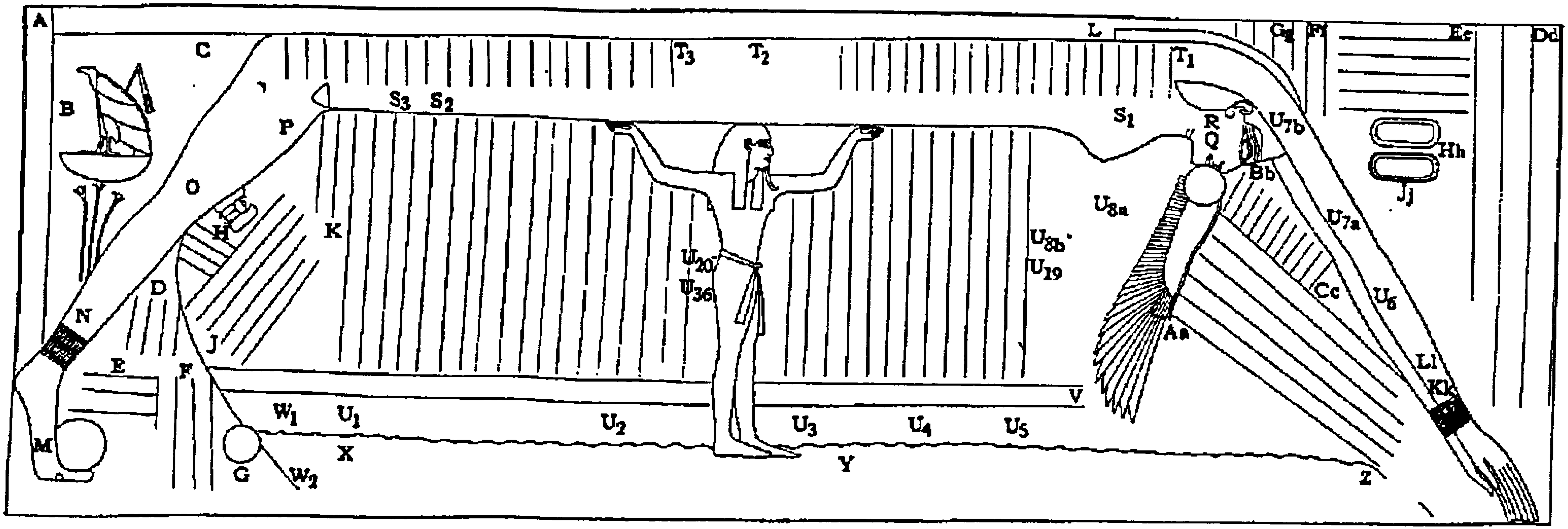

Figure 26: Index of texts in the Nut vignette in the Osireion

(from *Egyptian Astronomical Texts* 1)

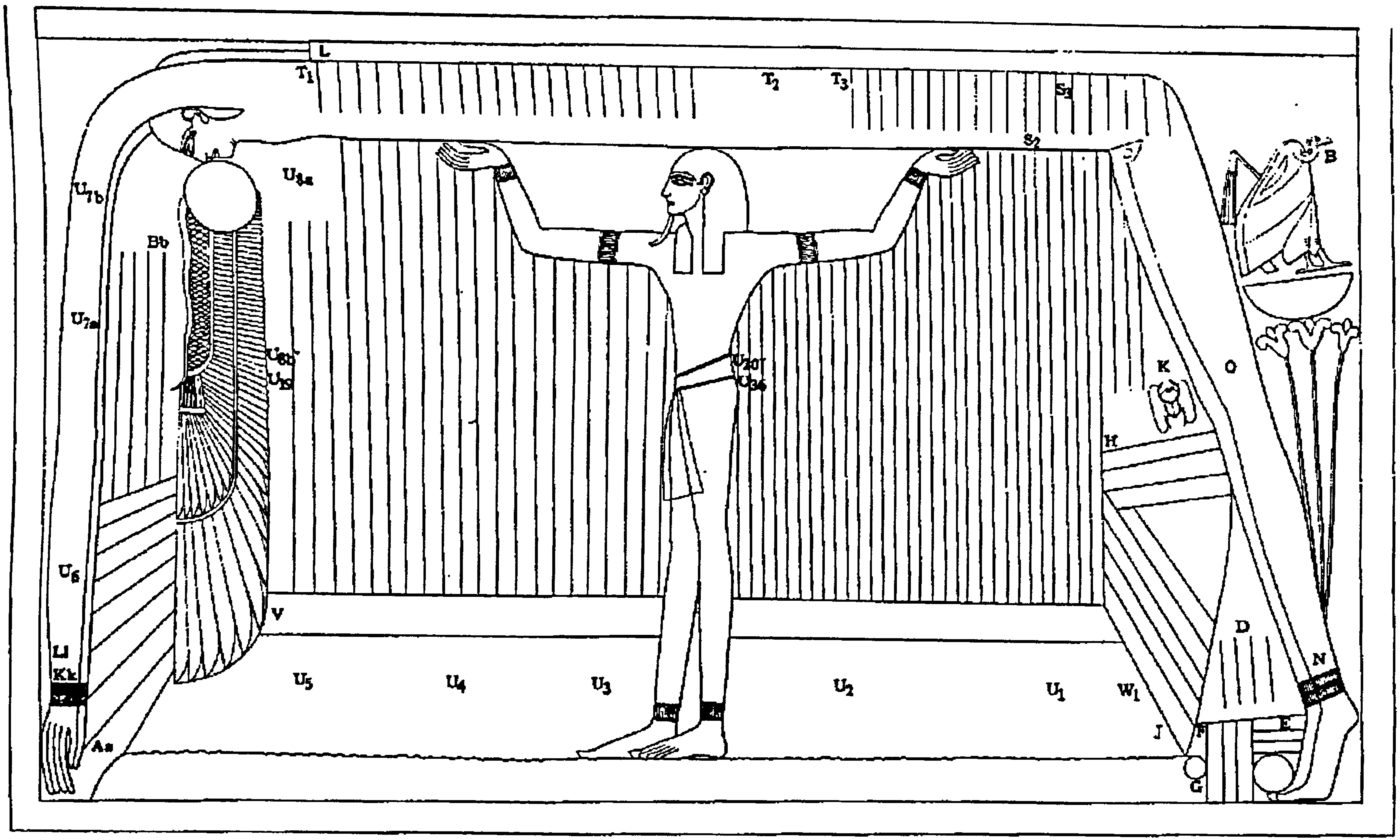

Figure 27: Index of texts in the Nut vignette in the Tomb of Ramesses IV

(from *Egyptian Astronomical Texts* 1)

The Nut Vignette Translation

The *Book of Nut* has already been translated, and extensively annotated by Parker in *Egyptian Astronomical Texts* 1. The following new translations follow Parker's translation notes except where stated[164].

The vignette consists of graphical components and text labels which vary in length from one word to several lines. The major figures are the goddess Nut, whose elongated body arches from her hands and head to the right (north) along the top of the vignette near the apex of the ceiling down to her feet to the left (south), and her father the god Shu who is centrally placed and depicted raising Nut above his head. This action, and its context in the Heliopolitan cosmology, is described in the *Book of the Divine Cow*, where the act of creating the sky is performed by Re (sitting on the back of Nut who is in the shape of a cow) to separate the ageing god from mankind.[165]

The texts in the Nut vignette divide conveniently into four categories:

1) star calendar, decan list, and decan labels
2) short labels
3) daily journey of the sun
4) region beyond the sky

The texts in the first category which have already been mentioned with reference to star clocks, using Neugebauer and Parker's system of labelling, are S '*sbššn, ṯs ꜥrḳ, wꜥrt*', D '*knmt* lives,[166] with *ꜥb* and *štw*. It is that Horus lives.', T_1 and T_3 the decan list, U the date list, V, W '*štw*

[164] The texts have also been translated by Allen (*Genesis in Egypt*) who presents a commentary. Allen's study is concerned with creation myths, and his commentary therefore concentrates on the aspects of the texts which relate to the shape of the universe. In his discussion of the path of the sun at the summer solstice (p. 5) he mistakenly states that the sun rises farthest north and sets farthest *south* on that day. The sun in fact sets farthest north. This error invalidates his subsequent discussion of the south-east and north-west areas of the sky (from text Dd, in which he follows F3 by reading 'south-eastern' rather than 'north-eastern' as it appears in F1) and his comments about the correlation between the use of the summer solstice as a basis for vignette texts, the date of the Osireion, and the coincidence between the summer solstice and the beginning of the civil year.

[165] Hornung *Der ägyptische Mythos*, Piankoff *The shrines of Tutankhamun*, Mayestre 'Le livre de la vache du ciel'.

[166] Or 'the life of *knmt*'.

lives, *knmt* lives' or 'the life of *štw*, the life of *knmt*' and X '... *knmt*'.

Three additional texts also belong to the first category. Kk and Ll seem to be labels which apply to the date set U_6.[167]

Kk	Setting in life in the Duat
Ll	Coming forth pure of evils

T2 is a label on Nut's body above the head of Shu and refers to a time when Sirius rose heliacally during the first month of Akhet, that is the first month of the civil year. This is representative of an ideal or original state.

T2	The act in the first month of Akhet at the time of the going out of Sothis

The complete text of V, which has already been discussed in Section B is

V Of that which is between the star which makes the first hour
and the star which is enclosed in the Duat: there are 9 stars
It is between the star which is born and the star which makes the first hour 20 decans,
giving 29 in those living and working in heaven.
One dies, another (lives) for the first decade.
It is therefore between the star which is born
and the star which is enclosed, 29 decades.
Issued under the length, issued to heaven as stars.

The second category comprises the five short labels B 'Nekhbet', P 'Eastern Horizon', Y 'Sand', R 'Evening', and Q 'Western Horizon' and the two texts Gg and Jj (which is damaged but mostly readable in the Osireion version while only a few words are preserved in Carlsberg 1) which describe the orientation of the goddess.

Jj	Her western arm in the north-western side, [ ] south-eastern.
Gg	Her head in the western horizon, her mouth in the west.

The texts Aa, Bb, Cc, and Z on the right hand side and A, E, F, G, H, J, K, M, N, and O on the left-hand side form the third category, while C, L, Dd, Ee, Ff, and Hh belong to the fourth category. These last two categories will be discussed in greater detail below.

Texts Concerning the Sun

The majority of these texts present aspects of the journey of the sun which are familiar from other religious texts. Reading the vignette from right to left, as was probably intended,[168] we

167 *Egyptian Astronomical Texts* 1 p. 87.
168 The scribe of Carlsberg 1 and 1a led Neugebauer and Parker to treat the texts in a certain order. The position of the Nut vignette at the head of the text, the direction of the majority of the writing and the order of

see that the sun enters the mouth of the goddess in the 'first hour' and enters the Duat in the 'second hour of her pregnancy'. The sun continues to exist inside the body of the goddess during the course of the night and stars accompany him.

This is of interest because the motion of the stars is linked strongly to sun both here and in the dramatic texts which follows. The stars are seen to move continuously, not just when they are visible to man, and follow the same general motion as the sun.

The notion of purification occurring in the Duat is taken up again in the dramatic text where the stars are purified in the Duat during their period of invisibility.

Aa The person of this god enters in her first hour of the ?evening.
He is enspirited and beautified in the arms of his father Osiris.
He is purified therein.
The person of this god sets in the Duat in her second hour of pregnancy.
Then the person of this god commands the Westerners and he makes plans in the Duat.
Then the person of this god goes upon the earth again developing in the southern land.
His powers become great like in the first acts in his primaeval time.
Then the great god develops as Behedet.
When the person of this god sails to the limits, the wonder of the sky is her arms.
He enters her ... in the night in the ?middle hour ....
When he sails inside her these stars are in his company.

Texts Bb and Cc contain the same themes, the vocabulary, style and content of which mirror that of the dramatic text.

Bb The person of this god enters her mouth in the Duat ?open
After, he sails inside her.
Just as these stars enter in his company, so they go in his company,
they ?run to their quays.
Cc These stars are in his company.

Text Z describes an underground aspect of the Duat

Z The houses of pillars is the place wherein is Re.

The remaining texts in this category are located on or near the legs and feet of the goddess on the left of the vignette. The sun is shown in pictorial form three times: twice as a circle

events described leads me to believe that the texts should not be considered to follow a strict order (being part of an image they should be absorbed in the same way as an image) but have a general right-to-left sense. This is reinforced by the notion that the text is primarily concerned with the stars and events during the night, so would begin with sunset on the right and end with sunrise on the left. Also, the text is describing cyclical events, and to read from left to right would be to read against this cyclical motion. That the scribe of Carlsberg 1 and 1a should follow the texts in the opposite direction is possibly an indication of the quality of his understanding of the text.

and once as a winged scarab flying up the leg of the goddess.

The order of the texts is clearly from lower to upper. The texts fall into three groups: those on the leg of Nut form one group while the other two are separated by the curved line stretching from below the 'sand' line up to Nut's knee. J, H, and K are to the right of this line, E, F, and G are to the left and M, N, and O are on the leg.

The text J talks about the sun preparing to rise. The preparation starts in the ninth hour of the night[169] as the sun grows in power. He reaches the region *msḳtt* which is the gateway between the Duat and the physical sky.[170]

J	Whenever the person of this god goes out from the Duat, these stars go with him to Mesqetet Then he grows in front of Mesqet. Then he is glorious and is embraced in the presence of his father in a shape on the east, the first time in the beginning. Then develops and ascends to heaven in the (9th) hour of her contentment. Then he is strong and comes into being in the two lands

After the preparation, the sun rises (text H) in the form of a winged scarab and flies up into the sky in strength (text K).

H	Then (he) has entered as/into this scarab. Then he develops just like he came into being the first time in the first land.
K	Then his heart comes into being, his strength comes into being. Then Geb sees the offspring Re when he goes forth

Below the curved line, texts E and G are difficult to understand. Neugebauer and Parker have taken both to include references to 'red'. In G this involved reading which has been used throughout the *Book of Nut* as a substitute for as standing for the Red Crown itself and thus having the meaning 'red'. This is suggested by Carlsberg 1 which writes the word *dšrt* 'red' in full and explains that the red crown, referring to the hieroglyph in the original text, should be taken to mean 'red'. In E there is more confusion[171] with Carlsberg 1 being

169 This reinforces the observation made in the previous footnote that the text is concerned with the night and describes events in order from sunset to sunrise.

170 *Msḳtt* has usually been translated as 'Milky Way'. Careful reading of funerary literature however, reveals that the region is frequently associated with portals, opening, admittance etc. (for example, *Coffin Texts* Spell 789, *Book of the Dead* Chapter 72) as well as with notions of crossing (*Coffin Texts* Spells 259, 336, and 622 *Book of the Dead* Chapter 58). Stars cannot cross the Milky Way and the sun is never seen to do so. The term is far more likely to represent a horizon/gateway/region concept rather than the Milky Way.

171 *Egyptian Astronomical Texts* 1 pp. 48-49.

little help.

E He opens .... he swims in his reddening.
G The red is after birth.

Text F is straightforward in comparison, with the sun finishing his purification in the Duat before returning to the sky. These three texts, by their position and by the content of F are concerned with the final acts of the sun in the Duat before rising.

F He purifies inside the arms of his father Osiris.
Then his father lives and he (Horus) is illuminated.
He (Horus) is placed before him (Osiris).

Texts M and O on the leg of Nut are concerned with actions performed by the sun in the course of rising

M The person of this god goes from her hindquarters/extremities
O He ... himself, he opens the ...s and eyes of his mother Nut.
Then he flies to heaven.

while N deals with what happens to the stars when these actions are performed. The style is equivalent to that found in the dramatic text

N Then enters the earth those who have risen and are born.

A final text dealing with the sun forms the left-hand border of the Nut vignette:

A This god is in her south-eastern side behind Punt.

He is about to travel in front of the dawn.

Texts Concerning the Regions Beyond the Sky

The descriptions of the areas beyond the body of the goddess Nut are representative of the Egyptian notions of 'that which does not exist'. Even where there is nothing, there are embodiments of emptiness and inhabitants of void. Here, primarily in the triangular region above Nut's arms and also in the text L which forms the top border of the vignette, we see that this region is characterised not only with the coldness and darkness that we associate with Space, but also by the moisture and marshiness of dank, dark places where the sun never shines.

L The upper part of this sky is pitch black,
its south, north, east, west limits are not known.
Those are fixed in Nun as the inert things.
There is no light of the soul there.
Nothing is known about the land south, north, east, west by the gods and spirits.
There is no light there
therefore every place shadow/empty heaven and earth is the ultimate Duat.

Dd Total darkness, cold water of the sky of the gods, the place from which the birds come.
These are from her north-western side, equal in her north-eastern side.
The Duat which opens is on her north side,
Her extremities in the east, her head in the west.

Ee These birds' faces are as peoples', their form is as birds.
One of them speaks to his other in the words of people.
They come to forage and provision themselves in Egypt,
They alight under the brightness of the sky.
That is the reason they come in the form of birds.

Ff The nests which are in the cold water of heaven.

Text Hh consists of two cartouches, one with chicks in (probably with the dual significance of a label meaning 'marsh'[172] and also a picture of the nest of the birds), one empty.

Text C is a difficult label appearing on the left-hand side near the picture of Nekhbet

C She appears ...

The Nut Vignette Texts in the Tomb of Ramesses IV and in Papyri Carlsberg 1 and 1a

The layout of the two sources is exactly the same in that no text is moved in the Ramesses IV version, although many are omitted. The main differences between the two designs stem from the different proportions of the spaces covered, the Osireion ceiling being long and narrow while the Ramesses IV version tends to the squarer. Consequentially, the N1 shape which Nut defines above herself in F1 is lost in the F2 version, together with the poetic texts it contained which referred to the region beyond the sky.

All the graphic elements of F1 are reproduced in F2 with the possible exception of the moon near P. The styles of Nut, the sun's wings, and the vulture differ, and Shu wears arm, wrist, and ankle bands in F2. Also the two cartouches near Hh and Jj are omitted in R4.

The area below horizon and legs is very cramped in F2, in contrast to the spacious display of texts in the Osireion. This is due to the 'horizon' not being so curved in F2.

All the simple 'labels' are omitted in F2, together with the repetitive text Cc. In fact M is the only text omitted in F2 for no apparent reason, although maybe space could also be cited here.

Epigraphically, F1 uses whereas F2 usually employs . F2 also exhibits a general

[172] Faulkner *Dictionary* p. 246 *sš*.

cramming of signs into groups, a symptom of the lack of space.

Comparison with the text included in F3 must take into account the order in which the scribe presents the texts (which is roughly mirrored in the order of labels assigned to the texts by Neugebauer and Parker) and the fact that some of the texts are said to come from a source called *sf*.[173] The first time the scribe mentions *sf* is in his commentary to the texts in the Nut vignette. Texts which seem to be part of *sf* are V, Bb, Z, Aa, Cc, Ff, Gg, Jj, Ee, Dd, and the dramatic text (first fourteen columns). We see that all these texts occur on the right-hand side of the vignette (Text V continues into the left-hand side). Prior to beginning *sf*, the scribe had dealt with texts A, C, H, D, E, F, G, J, K, L (from the book *sḳy*[174]), and T_2, all of which occur on the left-hand side of the vignette, except L which forms the top border of the vignette and T_2 which occurs above Shu's head in the middle of the body of Nut.

The texts omitted in F3 consist of the majority of the texts concerning the two decan lists and the star calendar text. An example date set from the calendar is however included F4 seems to include more date information which seems to relate to text U. As for the remaining categories of text, in general it is the shorter texts which are omitted in F3 with all the labels except the two containing orientation information and the three short texts M, N, and O omitted. Text Hh, the two cartouches, is a graphical element so would not be expected to occur in the text of F3.

Table 44 summarises the texts contained in the sources F1, F2, and F3 in the four categories introduced at the start of the previous section: texts to do with decans and the star calendar, labels, texts concerning the sun and texts about the region beyond the sky. Blue entries indicate that the text is considered to be part of the book *sf*.

We have now seen how the inclusion or omission of texts in the Book of Nut is due to spatial

173 Yesterday? Faulkner *Dictionary* p. 224.

174 Uplifting, exalting? The names of these two books seem to have to do with setting and rising. Could they be names for the two sections of the vignette?

considerations in F2 and to prominence in F3.

Decans etc.			Labels			Sun			Beyond		
F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
D	D	D	B	B	-	A	-	A	C	-	C
S_1	-	-	P	-	-	E	E	E	L	L	L
S_2	S_2	-	Q	-	-	F	F	F	Dd	-	Dd
S_3	S_3	-	R	-	-	G	G	G	Ee	-	Ee
T1	T1	-	Y	-	-	H	H	H	Ff	-	Ff
T2	T2	T2	Gg	-	Gg	J	J	J	Hh	-	-
T3	T3	-	Jj	-	Jj	K	K	K			
U	U	-				M	-	-			
V	V	V				N	N	-			
W_1	W_1	-				O	O	-			
W_2	-	-				Z	-	Z			
X	-	-				Aa	Aa	Aa			
Kk	Kk	-				Bb	Bb	Bb			
Ll	Ll	-				Cc	-	Cc			

Table 44: Concordance between texts from the *Book of Nut* in the Osireion (F1), the Tomb of Ramesses IV (F2) and in Papyrus Carlsberg 1 (F3)

The Dramatic Text

The text, a continuous piece of prose in a style usually termed a 'dramatic text', appears in forty-six columns, of which the first fourteen are in good enough condition to be read with certainty (Figure 28). A new translation of the first fourteen columns is presented here together with an analysis of the text and a discussion of the content. The translation falls naturally into thirteen verses, which do not relate to the layout of the text in columns. The translation stops in the fourteenth column at a suitable point. The portions of the text in square brackets are translations supplied from consideration of F3.

It is interesting to note that the commentary to the text supplied in F3 stops in the fourteenth column with the comment that the scribe could find no more of the book, which he calls *sf*. This is another indication that the version of the text the scribe was working from was no more complete than the version in the Osireion.

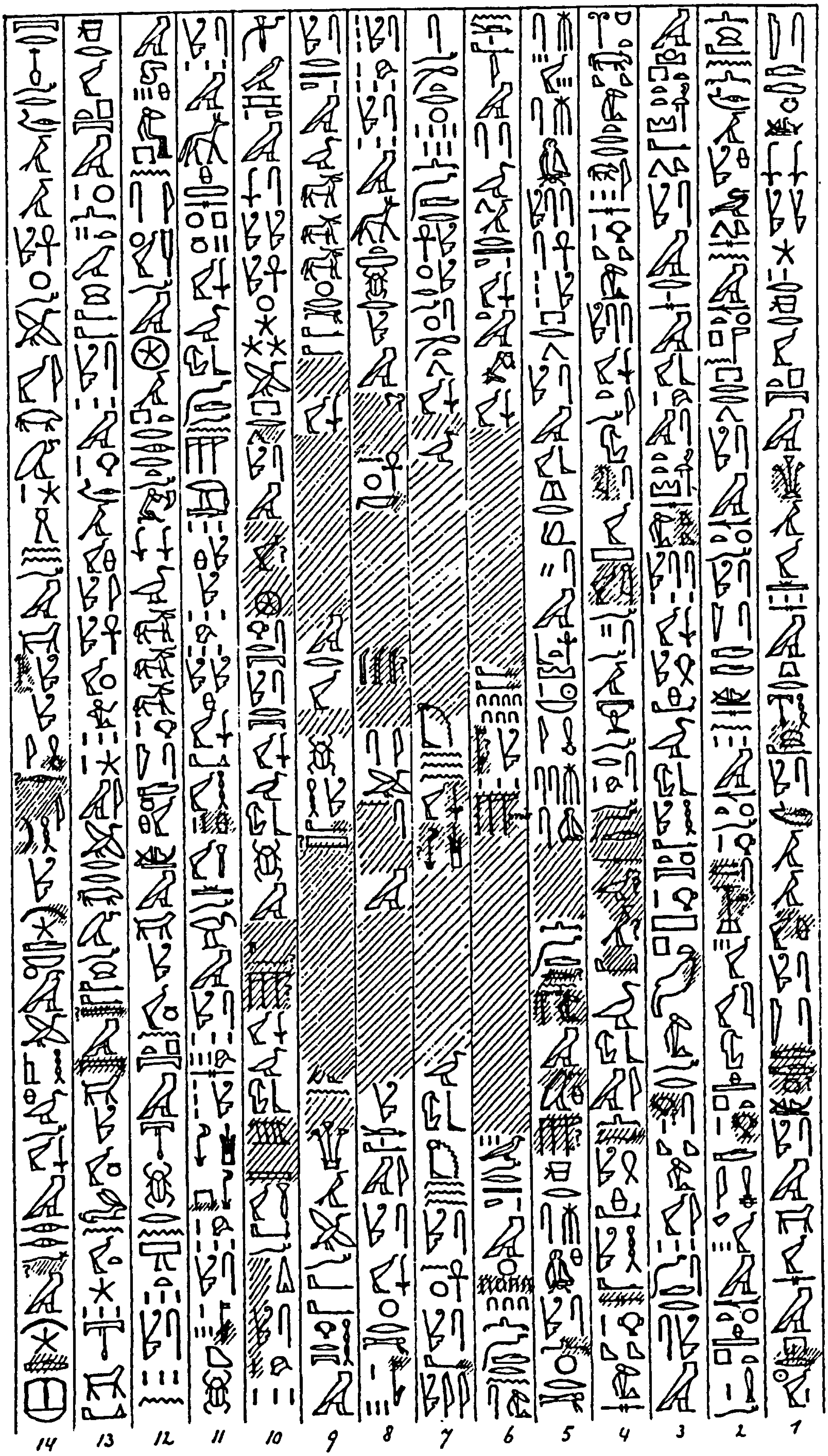

Figure 28: Dramatic Text from the Osireion after A. de Buck

(from Frankfort *The Cenotaph of Seti I*)

Translation

i When these stars sail to the limits of the sky from her surface in the night
they rise and can be seen.
ii When they sail inside her in the day
they do not rise and cannot be seen.
iii Just as they enter in the company of this god
so they go with him.
iv When they sail with him upon the supports of Shu,
they rest in their places after His Person sets in the western horizon.
v They enter her mouth in the position of her head in the west.
She swallows them.
vi Then Geb quarrels with Nut because he is angry because she is eating.
Her name is called 'sow eating her piglets' because she eats them.
vii Then her father Shu, he lifts her and raises her up to his head saying:
viii 'Be watchful, Geb.
Don't quarrel with her because she eats your offspring.
They will live,
They will go out from the place of her hind-quarters in the east each day
just as she bears [Re].
Her name is not called 'mother of gods' until she gives birth to them.
Not one falls from her.
ix The one who wanders to earth, he dies then.
[He is purified and gives up his misfortunes to the] earth in 70 days.
Her name is not called 'releaser' until 7 days.
The name is not called 'living' until he is released.
... makes him pure .... Geb. They are pure and living.
They will place their heads in the east.
As one becomes dead, another will live for a decade.
[They 'always' celebrate the first festival in the east.
The head of one is placed,] one of them.
Then their evils fall to the ground,
so that the souls who have fallen embrace [the earth.]
x The life of a star begins in the lake as a fish.........
It goes from the water's surface and screeches to heaven from the sea in its form.
The living stars fly, they go from the [Duat] and they fly up to the sky.'
xi Then Geb became [prince] of the gods.
Then Geb ... he commanded.... placed their heads in the east again.
Then Geb, he said to the gods: 'Pick apart your heads!'
Then Thoth commanded that they meet their heads.
They lived and their heads went out.
Burial happened for a period of time in the Duat because this is what the dead do.
xii The spirits go sailing the inside of the sky at night
it happens that they go to the limits of the sky in the day:
they are those which do not rise in sight there.
xiii Those that are seen by the living as stars,
they go and rise in the sky in the hours of the night
and sail in the sky in beauty seeing its life.

Discussion

The text is concerned with the motion of the stars as perceived by an Earth-bound observer and deals with both the diurnal and the annual motion of a certain group of stars, referred to in the text itself as *nn n(y) sbꜣ(w)* 'these stars'.

The first part of the text (i-v) records the observed general behaviour of the stars during the course of the night, a mythological drama follows (vi-xi) describing the annual life cycle of a star, and the final pair of verses (xii-xiii) summarise both the annual and diurnal cycles succinctly.

The verb *sḳdd* is used for the general motion of a star over the sky. The verb is causative, implying that the stars are not travelling under their own motive power, but are forced to move by some external cause. The doubling is typical of a second tense verb of motion indicating an habitual action. The choice of the water imagery of the verb 'to sail' with a boat determinative is very strongly connected with stars. As we shall see in a later section on astronomical tableaux, the figures depicting *spdt* and *s3ḥ* and the superior planets are shown standing in barques, and in the *Book of the Day* the sun is shown at each hour in a barque with his mode of propulsion changing over the course of the day.

The area travelled by the stars is the liminal region of the sky '*d̲rw pt*', formed by the skin or surface '*ḥ3w*' of the sky goddess Nut. The goddess is frequently depicted wearing a blue dress covered with yellow stars, or as naked with the stars on her skin, as is the case here.

The contrasting use of the active and the passive for the verbs *ḫʿ* 'to rise' and *m33* 'to see' used in verse ii links the behaviour or action to the effect of the stars: shining and being seen to be shining. This method is used again at the end of the section in verses xii-xiii.

Verse ii mirrors i completing four pairings of words, skin/inside; day/night; rise/not rise; seen/not seen; introduced by the same verb *sḳdd*. The continued use of this verb in a situation where the stars are not observable shows that the motion of a star was believed to be continuous whether or not the star was visible.

The third verse introduces 'this god', an appellation of the sun. The behaviour of the stars is being linked with that of the sun by correlation of two particular movements: the stars *ʿḳ* with the sun and *pr* with him. The usual meanings of these verbs, 'to enter' and 'to go' respectively, are replaced in astronomical contexts with 'to set' and 'to rise'. The doubled verb of motion *prr* indicates the recurrent nature of the motion. *M-ḫt* can be translated in a number of ways, 'in the following' or 'in the company' or 'in the entourage'. In the present context, it is best thought of as indicating an affiliation of behaviour with a loose positional connection.

Continuing the parallel with the sun, verse iv shows how, when the stars are high in the sky 'upon the supports of Shu'[175] at the end of the day, when the sun sets, the stars appear in the sky. This is pointing out that the stars do not all rise after the sun has set, but are already 'in their places' at sunset.

During the night, the stars pursue their westerly motion, set in the western horizon and are swallowed by Nut (verse v). Having dealt with her skin, the text now turns to her mouth. Geb, Nut's consort the earth-god, is seen as angry at Nut's apparent consumption of the stars, which appear to be regarded as her, and hence presumably Geb's, offspring. Their father Shu performs his separating motion at this point in the text, but it must be remembered that stars are setting continuously throughout the day and the night, so his action is not momentary but is also continuous.

Shu explains in a long speech (verses viii–x) what happens to the stars who are swallowed. These stars fall into two categories. The majority of the stars, Geb is told, will rise again the next day (the diurnal cycle of the stars). Nut will once more be a mother, rather than 'sow eating her piglets', when this happens. However, the second category of star follows a different path (verse ix) going into the ground rather than passing through the body of Nut.

175 See *Book of the Dead* Chapter 17 'As for that holy gate, it is the gate of the Supports of Shu. *Otherwise said:* It is the gate of the Duat. *Otherwise said:* It is the door through which my father Atum passed when he proceeded to the eastern horizon of the sky.' From Faulkner *The Egyptian Book of the Dead* pl. 8.

This process is called death, and the purification which follows takes 70 days. After this time, the star is 'pure and living' and will rise again. The event 'place their heads in the east' is a phrase describing the heliacal rise of the star which marks the end of the period of invisibility. Shu also notes the cyclical nature of these events, in that they occur to one star after another continuously.

The speech continues in verse x by likening the star during parts of its life cycle to a fish. This idea of fish usually occurs alongside tears and people and is due to the similar nature of the words in the Egyptian language. Here, the star flies up from the water into heaven.

Verse xi mentions heads again in an obscure section which relates an interaction between Geb, who commands the stars to rise heliacally, and Thoth, hitherto unmentioned, who seems to encourage not just their heads to appear, but the rest of the star. This can be likened to what happens after the heliacal rise of the star. Over the subsequent dawns, the length of time that the star is visible increases.

This verse is also vitally important because of the link it establishes between the period of invisibility of certain stars (70 days) and the customs surrounding death and burial. This ties in with the conjecture that the decans were originally chosen to mark the period between death and burial, and that their use to mark hours during the night was a development from this earlier function.

Verses xii and xiii are a pair, summing up the diurnal and annual cycles. The stars which are high in the sky during the day and are inside the goddess during the night are completely invisible, while those that are outside the goddess at night can be seen as stars.

Cosmography of the *Book of Nut*

The three sections of the *Book of Nut* together attempt to describe the entire celestial mechanism of the sun and the rising and setting stars.

The text is unique in Egyptian literature because its combines the mythological creation scenario with a detailed description of the motion of celestial bodies. The text illustrates the way physical phenomena outside the range of direct human perception were described in ancient Egypt. We see that the language and style used is very different from that which we would expect in a scientific document.

Discussion of the *Book* has led to some important information concerning the Egyptian perception of the sky.

Firstly, the cyclical nature of celestial events has been strongly emphasised. The text bases its discussion of the movement of the stars on the behaviour of the sun, which is cyclical on a daily basis. The text shows that the similarity between the stars and the sun is not complete, and describes the effect of the difference between the solar day and the sidereal day, which is that the stars follow a second cycle on a yearly scale.

Secondly, we see that the portion of the sky travelled by the sun and the rising and setting stars is represented by the goddess Nut. The image of Nut being raised above Geb (the Earth) by Shu (air) is a recurrent and common motif drawn from the creation tradition that describes Atum as the father of Shu and the grandfather of Nut and Geb.

Parts of Nut's body are used to describe different stages in the daily cycle of the sun and the stars. In particular her mouth, where the sun and stars set, her vagina where they are born, and her skin over which they sail. Also in the daily cycle, the stars and sun travel within her body after they have set. In the annual cycle of the stars however, the star which becomes invisible is not seen as being inside the body of Nut, but instead goes to the earth and rises from the water.

Thirdly, we find specific information about the motion of the stars in terms of references to the seventy-day period of invisibility and the star calendar itself. This strongly suggests that 'these stars' are the group of timekeeping stars known as decans. It is not clear whether all stars which rose and set (that is all visible stars except the circumpolar group) were thought to exhibit this same behaviour.

Fourthly, we note that the Egyptian world picture did not only describe things which were visible to man, or state that things which are not visible are wholly spiritual. Instead, the stars which are not visible are still considered and their motions described. The areas which are not visible still exist and are populated by beings which exhibit similar behaviour to existing visible beings.

Finally, the way the Nut vignette is arranged indicates how cyclical events in time are portrayed on two dimensional static media. Things that occur in a temporal sequence are depicted as lists, while time is also shown as flowing from the right to the left for the daily cycle and in a flow under the body of Nut from right to left and under the sand line from left to right for the annual cycle. The same object is shown in different positions in different aspects to show motion through space and time (the sun as a disk, a scarab, and a winged disk) and graphical elements are used to separate areas concerning different aspects of the situation and to serve as parts of the text (in the case of the scarab, for example). The arrangement is complex and comprehensive, with a fusion of text, graphics, and layout which together show far more information than a linear text is capable of conveying.

The *Book of Nut* and Astronomical Timekeeping

The *Book of Nut* gives an indication of the extent of the astronomical knowledge possessed by the priesthood during the New Kingdom. Contained within the texts, as we have seen, is a knowledge of the movements of the stars which is interesting in its selectivity. The stars pursue an east-to-west motion as does the sun. This link between the night-time stars and the daytime sun is emphasised by the use of the phrase *m-ḫt*, 'in the company', 'in the entourage'. The difference between the regularity of the sun's reappearance each dawn and a star's disappearance from the sky for a period during the year is noted and explained in a myth concerning death and purification. From the vocabulary contained within the dramatic text that describes this portion of the annual cycle, we derive support for the theory postulated earlier that the disappearance of the decanal stars was linked to the period between death and burial, and that the diagonal star clock was developed from a list of stars intended to mark the passage of a longer period of time, around seventy days.

The dramatic text states the time period of 70 days explicitly. Is it reasonable to assume that this period of decanal invisibility was inflexible? The answer is clearly 'no'. The reasons for this stem from the practical and logical barrier to a fixed period being set between two near-horizon naked eye observations, the heliacal rise and set of a star. Practically, as has already been noted with reference to stellar timekeeping, the dates of heliacal rise and set are dependent on the nature of the object, the location of the observer, and the observing conditions. On an even more basic level, the observer must be physically capable of seeing the star (that is, he possesses average eyesight) and must be able to identify the star correctly. The logical reasons against 70 days being a fixed, immutable figure for the disappearance of a star include the random distribution of stars and the argument that '70 days' is a round figure that is likely to be representative rather than definitive.

Throughout the Egyptian religious culture, we find the notion that a rough representation in the real world will be transformed into a precise, working object in the spiritual world. Just as we can use the idea of bright, evenly placed stars as a model for illustrating how a diagonal star clock functions, with the understanding that a 'model' in our modern, scientific sense represents an ideal or simplified version of reality, the Egyptians would apply the same reasoning to physical models: they contained the essential components, properties, and configuration of the real object, so in a sense they were identical with the real object.

It is with reluctance that a modern, scientific mind admits that, in the case of the 70 day period of invisibility of the decanal stars, as in the case of many promising pieces of 'data' in the field of Egyptian astronomy, no equations can immediately be brought to bear on this piece of information which will for once and all unravel the mystery of identifying the Egyptian constellations.

Furthermore, this text demonstrates another feature of Egyptian thought concerning the cosmos. Nothing happened without cause. The separation of Earth and sky was an act of a god. The setting of the sun and the stars was caused and justified each day and night. The reappearance of a star was ordered by a god. These events, which presumably humans then as now take for granted, were significant acts occurring in the spiritual world in a strange process of happening once but being repeated forever.

The text of the *Book of Nut* gives a feeling of cyclical continuity which is slightly different from our notion of the continuity of time. There is a slight hesitation, a need for conflict between the actors, a sense of renewal of the action at each repetition, and the danger of the slightest imbalance occurring causing the whole process to be altered slightly or catastrophically.

These themes are continued in our next text, the *Book of the Day*.

Section G: The Book of the Day

Introduction

The *Book of the Day* is one of a pair of religious texts that first appear in the New Kingdom. Its companion text, the *Book of the Night*, is similar in overall plan and content to works such as the *Book of Caverns* and the *Book of Gates*, and contains nothing of an overtly observational nature which is relevant to the present study. The *Book of the Day*, however, is of far more interest. As its name suggests, the *Book* describes the events surrounding the sun in the daylight hours.

Aspects of the text are of pertinence to the study of the daylight timekeeping methods, the shadow clock and the sloping sundial, and one portion of the text provides important and unique information about the circumpolar region.

Sources[176]

G1 Tomb of Ramesses VI (KV9), ceiling of the Sarcophagus Hall

G2 Tomb of Ramesses VI (KV9), ceilings of Corridors C and D and of Hall E

Later versions of the text appear in the tomb of Ramose[177] (of the time of Taharqa in XXVIth dynasty), the tomb of Harwa (TT37, XXVth dynasty),[178] and in the Ptolemaic temple of Edfu, without the graphical elements.[179]

Layout of the Book of the Day

The *Book of the Day* appears twice in the tomb of Ramesses VIth. G1 is contained within the space defined by the body of the goddess Nut. This daytime Nut is back-to-back with a night time Nut which arches over the text of the *Book of the Night*. The *Book of the Day* is

176 Versions G1 and G2 appear in Piankoff *Le Livre du Jour et de la Nuit.*

177 Piankoff *Le Livre du Jour et de la Nuit* p. xi fn. 2.

178 Tiradritti 'Three years of research in the tomb of Harwa', the text is too fragmentary for any analysis (private communication with Tiradritti).

179 See also Naville *Deir el-Bahri* pl. CXIV ritual for each hour of the day and the night (fragmentary). Hours of the night were also used as divisions in Gates and Amduat, but these works have little relationship to naked-eye astronomy and so are not dealt with in this study.

arranged on five registers. The uppermost register and the two lowest registers contain processions of deities. The second register contains barques representing eight hours of the day. The middle register contains the bulk of the text.

In G2, the pair of texts *Book of the Day* and *Book of the Night* both occur under a single Nut. The *Book of the Day* is near the body of the goddess and contains four registers, the upper pair separated from the lower pair by a band of water. As in G1, the majority of the figures face towards Nut's head. The barques sail in the second register, with their texts in the third. The first and fourth registers contain processions of deities. Towards the 'dawn' end of the text, figures adoring the dawn face in the opposite direction, as they do in G1.

The entire text of the *Book of the Day* has previously been published by Piankoff, who labels each text with a number denoting the register (1 to 5 based on the layout of version G1) and a letter. The barques sail from left to right from the birth of the sun to its setting in the west. The majority of figures conform to this left to right orientation, as does the order of the columns of text, although the hieroglyphic figures within the text face to the right. Much of the text consists of labels for the figures, while longer portions of text relate to effects which occur during each hour of the day. In this study, we shall mainly be concerned with texts and figures which appear in the second and third registers of G1. Figure 29 shows the layout of these registers.

Hour Barques of the *Book of the Day* in the Sarcophagus Hall

The hours specifically named in the text of the *Book of the Day* are:

Text 5c: 2nd hour '*ḫsrt kkw*'
Text A: '*sḥtp.n=s*'
Text 3c: 6th hour called '*ʿrwt-nḏrt*'
Text 3e: 7th hour '*ȝwt-ib*'
Text 3f: 8th hour '*dwȝ-ḥʿt*'
Text 3g: 9th hour '*nbt-ʿnḫ*'
Text 3j: 10th hour '*wp št biȝ sḳb ḳbḥ ḥpwt*'
Text 3k: 11th hour '*nfrt dgi*'

Figure 29: Layout of the second and third registers of the *Book of the Day* in the Sarcophagus Hall of KV9

Text 5c is on the lowest register, text A spans the three highest registers, while the remaining texts are on the third register.

A total of fourteen barques are depicted in the *Book of the Day* in the Sarcophagus chamber. The four smallest unmanned craft probably are only included as an indication of 'water' and occur in two pairs: one pair near Nut's mouth, the other in the water flanking the two smallest manned barques under the winged scarab at the opposite end of the *Book*. These two small manned barques are different in character from the remaining eight barques. They face each other with the sun disk containing the image of a small child between them. On board we see that they have the same configuration: two steering oars, a low shrine with ?leaves growing from it, a goddess (labelled Isis in the lower and Nephthys in the upper barque) and a shrouded prow. The two uraei flanking the infant sun disk are both labelled Mehen.

The larger barque (which we shall call the third barque) to the left of this pair is similar to the seven barques of the second register. It is a transformation of one of the two small barques. A pair of gods labelled *ḥw* and *siꜣ* have appeared in front of the steering oars, the leaves have developed into a larger plant, two mats and a bundle of hunting implements have been added, and there are now three figures in the prow, which is still covered. The first figure is labelled Shu and is performing the act of raising up Nut, who is above him giving birth to the sun disk. The second figure appears to be double. Four labels occur between Shu and this figure: *gb*, *ꜣst*, *ḥr* and *ḥkꜣ*. Since *ꜣst* seems to be a misplaced label for one of the two goddesses attending Nut, we assume that one of the three remaining names applies to the hare-headed figure in the prow and the other two to the doubled figure of the man.

The fourth barque is on the second register. The steering oars themselves are labelled as *ḥw* and *siꜣ*, and have no figures for these gods. The mats and plant are replaced by a naos containing the sun-god. More people have arrived in the prow, and the hare-headed god, as we would expect, is clearly labelled *gb*. This process of transformation continues from barque to barque along the second register. The prow of the barque is covered in the two small barques and the first two large barques, as well as the last two large barques. This represents the dimmer, lower sun in the morning and in the evening.

In front of the fifth barque, a confrontation occurs. 'The enemy', the serpent Apep, is sighted. Serpents spit at him (text 2b) and he is attacked by knives (text 2c). The struggle lasts three hours, from the sixth hour (text 3c) to the eighth (text 3f).

After the eighth barque, in the ninth hour (text 3g) the deities enter the Field of Rushes[180] (labels 2g and 2f), which is described in texts 3h and 3i in the register below the representation of the Field.

The tenth hour sees the barque manned once again, but it is now referred to as the 'night barque' *sktt* (text 3j), and its prow is shown covered. Finally in the eleventh hour, the process of mooring is described 'as the barque descends upon the west' (text 3k). The barques of the 10th and 11th hours are identical.

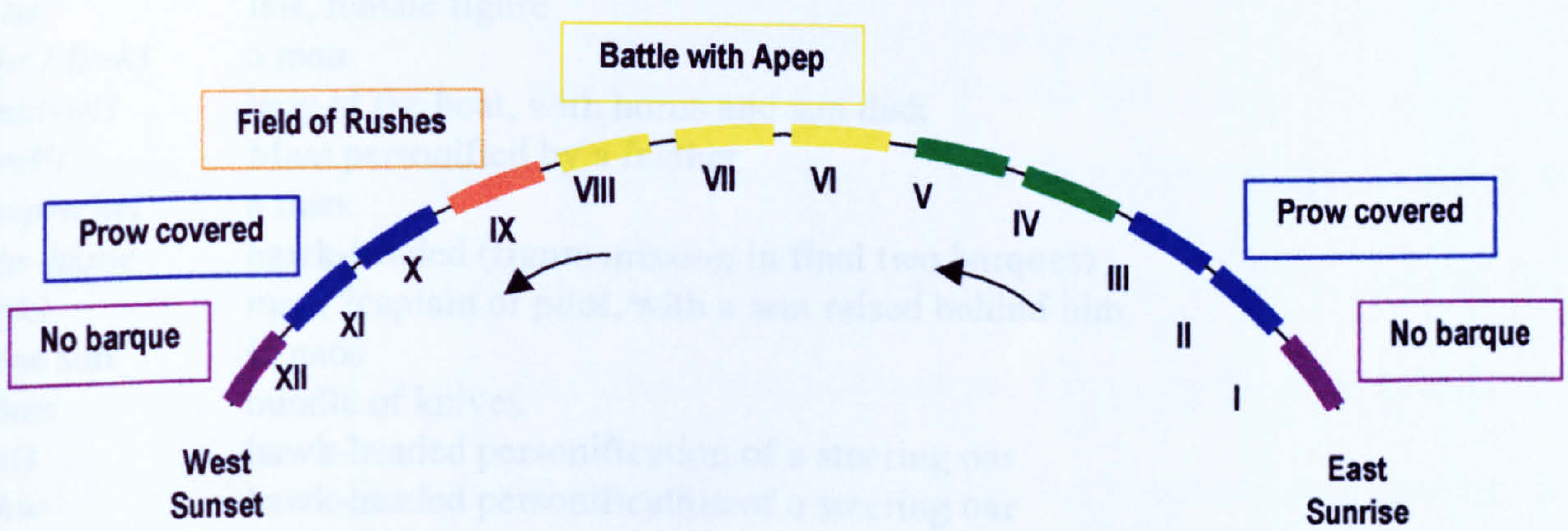

Figure 30: Progress of the sun during the day, according to the *Book of the Day*

180 A celestial region referenced frequently in funerary literature. For example, in the *Coffin Texts* Spell 30, Chapter 72 of the *Book of the Dead*.

Counting back through the hours, the eleventh is represented by the seventh barque on the second register, the tenth hour by sixth barque and so on. The leftmost barque on the second register should represent the fifth hour. In the next section, we shall see why this is probably not the case.

The changing crew and cargo of the barque is not random. The bundle of hunting implements, for example, disappears after the serpent is first attacked, because these are the weapons that are used in the attack. The deities in the barque are renamed and redrawn as their aspects or functions change. *Ḥw* and *sȝ*, the steering oars, are always present in their pictorial form of a pair of oars and sometimes as figures and labels. Throughout the barques of the second register *ḥkȝ*, *ḥr-ḥknw*, *nbt-wȝ*, and *gb* are included in the crew.

The small figure of a woman is present in all the second register barques with uncovered prows, while her label *sʿryt* occurs in all barques from the sixth hour onwards. She must therefore be a lookout, who is blinded by the covering or the dimness it represents.

A complete list of the occupants of the barque from prow to stern is given below:

Name	Description/function
sʿryt	lookout (figure covered by reed mats in the final hours)
gb	hare-headed with long pole (for sounding or punting?)
ȝst	Isis, female figure
ḥr / *ḥr-kȝ*	a man
nbt-wȝ	lady of the boat, with horns and sun disk
mȝʿt	Maat personified by a feather
wp-wȝwt	a man
ḥr-ḥknw	hawk-headed (figure missing in final two barques)
ḥkȝ	man, ?captain or pilot, with a arm raised behind him
the sun	in naos
šms	bundle of knives
sȝ	hawk-headed personification of a steering oar
ḥw	hawk-headed personification of a steering oar

Hour Barques in the *Book of the Day* in Corridors C and D and Hall E

The three barques sideways on to the registers are very similar in disposition and contents to those in G1, with a slight rearrangement of the largest allowing Shu to remain directly under

Nut, and the inclusion of ?mats and the bundle of knives in the two small barques. There are nine barques in the second register, compared with just seven in G1. Of these, the barques of the ninth, tenth, and eleventh hour (which all occur in one section of corridor) correlate exactly with those of G1, as do the three preceding barques (sixth, seventh, and eighth hours) in the next section of corridor which include the fight with Apep. The first barque on the second register is towed, like the first barque in the second register of G1, and correlates with it. The next two barques are therefore at variance with the other version.

In general, the barques are more populous in G2. *Ḥw* and *sl3* are always personified and *sʿryt* is shown whether the prow is covered or not.

The total crew list is as follows:

sʿryt	lookout (figure covered by reed mats in the final hours)
gb	hare-headed with long pole (for sounding or punting?)
3st	Isis, female figure
ḥr-k3 ?	a man
	a hawk-headed figure
ḥr-k3 ? *wp-w3wt*	a man
wp-w3wt ?	a man
nbt-wl3	lady of the boat, with horns and sun disk
ḥr-ḥknw	hawk-headed (figure missing in final two barques)
ḥk3	man, ?captain or pilot, with a arm raised behind him
the sun	in naos
	two mats
sl3	hawk-headed personification of a steering oar
ḥw	hawk-headed personification of a steering oar

In addition, a bundle of knives appears in the large barque at right-angles to the others and in the first barque of the second register and plants appear in the two small barques and the large barque at right-angles to the others, and the penultimate barque on the second register.

This version of the text has suffered greater damage than G1, and labels are often missing. It is therefore difficult to ascertain who are the extra two members of the crew (one hawk-headed figure and one of the three 'men').

We must now address the discrepancy between the numbers of barques in the two versions.

There are two possibilities: either G2 inserts two extra barques (the second and third on the second register) or G1 omits two. The latter is much more likely. The two small sideways barques are now not part of the run of hours of the day, and the larger sideways barque becomes the representation of the second hour. This means that G1 omits the fourth and fifth hour barques.

The Course of the Sun

We are now in a position to assess the ideas behind the *Book of the Day* in relation to what we already know about the daylight hours from our study of shadow clocks, given that the earliest occurrence of the *Book of the Day* dates from the New Kingdom, as does the earliest extant shadow clock.

The *Book of the Day* implies the division of the day into twelve hours. The earliest hour of the morning and the last hour in the evening are treated differently in the both versions of the *Book*, with no barque being depicted. The barques of the second and third hours, and the barques of the tenth and eleventh hours have covered prows.

These features indicate that the journey of the sun through the sky was divided into distinct phases. The first and last hours of the day were transitional periods between day and night. For the second and third hours, the sun had not reached full strength. In the fourth and fifth hours the sun sails unobstructed, but during the sixth, seventh, and eighth hours the struggle with Apep occurred, resulting in triumph over the enemy. The party then land at the Field of Rushes, which marks the beginning of the evening, when the sun decreases in strength, the prow is again covered and the embarkation of the night barque is being prepared.

The battle with Apep takes place around midday. The sun, having risen higher in the sky all morning, is apparently slowed down by the struggle, and seems to pause in its ascent. The relationship between the evening and the Field of Rushes, a land connected with the most pleasant and desirable part of the Otherworld, is similar to our ideals of an 'evening of life' of comfortable retirement.

This mythical interpretation fits with our physical perception of the daily journey of the sun: the ambiguity between day and night at dawn which leads to three modern formal definitions of 'twilight', the veiling of the sun through the thickness of the atmosphere and clouds on the horizon, the ascent of the sun, its similar altitude over the midday period, its descent and approach to sunset in a symmetrical manner compared with the events after dawn.

The difference between the *Book of the Day* and other texts dealing with the journey of the sun during the night is observation. The *Book of the Day* is describing a process which everybody is aware of in daily life. The other texts deal with unseen mythical regions. That the *Book of the Day* uses similar ideas of barques, conflicts, and processions of gods cannot obscure the relationship between the *Book* and the reality of the sun's apparent motion across the sky.

The Circumpolar Group in the *Book of the Day*

One portion of the text of the *Book of the Day*, labelled 31 by Piankoff, relates a myth about the figures which comprise the circumpolar group. The text mixes familiar names with obscure concepts and, like other texts from the *Book* uses enigmatic writing for some words and phrases.[181] The new translation presented below allows the text to fall into verses which are headed by thematic sentences.

Translation

The 4 northern spirits are these 4 gods of the entourage
> who ward off the storm in the sky in the time of the great war,
> who seize the prow-rope,
> and control the stern-rope in the barque of Re
> with the crew of the Imperishable Ones,

[181] Drioton in Piankoff *Le Livre du Jour et de la Nuit.*

the 4 northern stars of Meskhetiu.

They shine in the midst of the sky, in the southern region of Orion,

they return to the western horizon.

As for Meskhetiu, this foreleg of Seth,

it is in the northern sky tied to the two mooring posts of flint by a cord of gold,

it belongs to Isis as a female hippo, its guardian,

its Water-of-the-Gods surround as stars, the horizon dwellers.

Re placed them in its (Meskhetiu's) company with Isis, saying:

'Beware lest it goes to the southern sky, to the Water-of-the-Gods.

Become Osiris who is in the company of Orion.'

The lords of the [Busirite] nome (Spirits-of-the-Flame are their names),

their town is Crete, in a country (Peb is its name), in the God's Northern Land

their forms are in the regions of the sky in the northern sea.

It is theirs.

This country of theirs is the northern horizon.

Discussion

'The four northern spirits'[182] may refer to the four jackals in the morning side in both versions of the *Book,* and additionally on the evening side in G2. Four jackals also appear at the sunrise end of *Book of the Night*. The 'entourage' is that of the sun.

The 'storm' and 'great war' contain symbolism of Seth in the *nšn*-storm, and evoke the Horus-Seth struggle. However, in the connection of the bark of Re, the diurnal battle with Apep is also recalled. This struggle, containing elements of a battle, a sandbank, and overthrowing of enemies has elements in common with the battle of Nedyt in the Osiris mysteries.

As well as including references to the nautical nature of the sun's vehicle, the next few lines remind us that the sun himself has no intrinsic motive power in Egyptian mythology. The boat must be towed, rowed, or sailed to make it move, and he relies on his entourage for the resources he needs for his journey. Here, the crew is said to include the circumpolar stars, specifically four stars belonging to Meskhetiu. These are probably the four bright stars that

[182] The word for spirits, *b3w*, is written enigmatically.

make up the share of our Plough, or the shoulder of the Foreleg.

The next line begins with 'they'. Since the circumpolar stars cannot possibly be in the region of Orion, it is assumed that this 'they' refers to the four gods of the entourage, which move in the same area as the sun and can therefore be in the 'southern region'.

The phrase *ḥry-tp*, here translated as 'midst', does not seem to have any concrete astronomical meaning. It has the nuance of being amongst, but no rigorous link to meaning 'in the exact centre' nor any other such exact positioning. The second piece of positional information *m ʿ rsy s3ḥ* in or from the southern region of Orion (in G2: *m ʿ s3ḥ* in or from the region of Orion), is much easier to understand.

Ramesses VI reigned from 1151 to 1143 BC. At that time, Orion rose so that the approximate azimuth of the belt at the ideal horizon was 100° and set so that it was 260°. Since the angular extent of the figure of Orion is around 20°, this means that the portion of the constellation we think of as representing Orion's head rose and set nearly due east and west.[183]

The path of Orion across the sky and the southern horizon bound a southern segment of the sky. The spirits, despite being called 'northern' in the first line seem to be more allied to the sun than to the circumpolar group.

The next section of the text is thematically labelled (using the particle *ir*) as dealing with Meskhetiu. From the vocabulary used, it is immediately obvious that the myth of the purpose of the circumpolar group is the subject of the section.

We find that the female hippo serves as a guard to the Foreleg. The symbolism of the

[183] The azimuth of the setting place decreased, and that of the rising place increased, for times before 1143 BC roughly at a rate of 5° per millennium. If the work was written or was referring to an earlier time, the rising and setting places would be more southerly. Since we are discussing general behaviour in a literary work, this does not affect our conclusions.

tethered Foreleg is very clearly linked to the behaviour of the asterism in the northern sky. Its revolution about a fixed point is very reminiscent of the behaviour of a tethered creature. Again in this passage we see the cause-and-effect basis for the myth. The behaviour of the Foreleg is accounted for by explaining that the stars are physically prevented by order of the sun-god from wandering into other parts of the sky. The Foreleg itself is the object of attention, the other members of the circumpolar group are merely there to enforce Re's edict. The consequences of the Foreleg escaping from its region are presumably dire, resulting in a confrontation between the old enemies Seth and Osiris in their celestial forms of the Foreleg and Orion. The other celestial figures therefore have the vital task of maintaining the balance by restraining the Foreleg.

The *mw-nṯr(w)*, the Water of the Gods, appears to be the liminal horizon area. The word appears in 31 twice, once with the male singular possessive pronoun attached.[184] To whom this pronoun refers is not clear. Previously *sȝ(w)t=f*, its guardian, is clearly the guardian of Meskhetiu itself. For *mw-nṯr(w)=f* it is possible that the suffix is part of the name that is included or omitted in different variants of the writing, or possibly Meskhetiu could again be cited as the possessor, or Re the dominant 'he' of many texts could make his appearance here instead of in the next phrase.

Another interesting aspect of this text is the way positional information is reported. We have various regions mentioned, some relating to physical areas (the circumpolar region) others to areas which are mythical or have mythic aspects (the God's northern land, Peb etc.). Even when these descriptive phrases supposedly relate to a part of the sky, it remains problematic to theorise how the parts of the sky were designated and described. There is no problem with east and west horizons, it is clear that these are areas associated with rising and setting

[184] *Mw-nṯr(w)* also appears in text 4a, also in connection with the jackals.

respectively. More precision is not required in the present context. More problems occur with the terms 'north' and 'south'. Although these are clear when applied to the flat terrain extending to the horizon, their use in a celestial setting is not so clear.

The modern interpretation of a celestial object being 'northern' is that the object is closer to the north celestial pole relative to another object, or that it is in the northern celestial hemisphere. We are happy with the idea of two star maps labelled 'northern sky' and 'southern sky' and would expect to see them overlap at the celestial equator. We are equally happy with describing Orion as 'north of' Sirius even though Orion currently lies on the celestial equator and the attitude of the objects changes relative to our horizon as they cross the sky.

Being as literal as possible, and accepting the horizon as the most likely datum for a people without developed geometrical skills, 'northern' means 'closer to the north point on the horizon'. Dividing the apparent celestial vault into two halves using a great circle from east to west on the horizon passing through the zenith gives both north and south halves, and also gives meaning to the relative terms 'north of....' and 'south of.....'. In reality the motion of the stars around the north celestial pole (and not the north point on the horizon, since the observer is not at the equator) means that the stars on the edge of the circumpolar region take turns at being most northern.

The terms 'northern stars' and 'southern stars' have usually been considered to be alternative designations for 'Imperishable Stars' and 'Unwearying Stars'. The circumpolar Imperishable Stars are both in the region of the northern horizon and in the region of the north celestial pole. By default, all the other visible stars, the Unwearying Stars, must be called southern.

Additionally, we have seen how certain decanal stars or asterisms were named *ḥry* and *ẖry* 'upper' and 'lower'. This labelling is again open to several interpretations: that 'upper' meant more northerly, or rose first, or was considered to be in the upper part of a celestial figure imagined to be described by the pattern of certain stars. The adjective 'southern' was also used in decan names (*smd rsy*).

We have already noted the lack of an identification of a phrase meaning 'north-south meridian'. The phrase *ḥry-tp* which we have translated as 'in the midst' could conceivably indicate 'zenith',[185] but with our current understanding of vocabulary in astronomical contexts, we can only say that the celestial positional terms in this passage seem to designate general areas rather than specific points. There is no indication that 'north', 'south', 'east', and 'west' were meant to have the standard of precision in the celestial context that we know was achievable terrestrially in the Old Kingdom for the cardinal alignment of pyramids. However, the small amount of literature containing information of the kind we see in text 31 does not preclude the possibility that a vocabulary of common words was used with special astronomical meaning for the limited purpose of describing the sky.

185 In *Coffin Texts* Spell 328 Faulkner translates *iskn* as 'zenith' following Sethe *Übersetzung und Kommentar* II 338.

Section H: New Kingdom Celestial Diagrams

Introduction

During the New Kingdom, the decanal stars appear in a new context, the celestial diagram or astronomical tableau, usually occurring on the ceilings of tombs and mortuary temples. The diagrams themselves have no practical timekeeping purpose, presenting the decans simply as a constituent part of the sky, but may be part of a larger decorative scheme involving Ramesside star clock tables or in one case forming the external decoration for a water-clock.

Sources[186]

H1 Tomb of Senmut

Ceiling of Tomb 353 at Deir el-Bahri. Time of Tuthmosis III.

H2 Karnak water-clock

From the reign of Amenhotep III.

H3 Tomb of Seti I

Ceiling of Hall K in KV17.

H4 Temple of Seti I at Abydos

Ceiling of Second Osiris Hall.

H5 Ramesseum

Ceiling of the central aisle of the Second Hypostyle Hall.

H6 Temple of Ramesses II at Abydos

Ceiling of Second Octo-style Hall.

H7 Tomb of Merneptah

Ceiling of Hall J of KV8.

H8 Tomb of Tausret

Two ceilings from KV14, one (Hall L) much damaged but apparently the same in layout and content as the better preserved ceiling (Hall J).

H9 Medinet Habu Ceiling I

[186] Brief descriptions of all the sources, as well as plates or diagrams, can be found in *Egyptian Astronomical Texts* 3 pp. 10-38, where Neugebauer and Parker's source numbering system is as follows:
H1 = 2, H2 = 3, H3 = 6, H4 = 7, H5 = 8, H6 = 11, H7 = 13, H8 = 14 and 15, H9 = 17, H10 = 18, H11 = 21, H12=23, H13=22, H14 = 24, H15 = 26 and 27, H16 = 28 and 29.

Ceiling of the Sanctuary of Osiris.

H10 Medinet Habu Ceiling II

Probably from the Second Hypostyle Hall.

H11 Tomb of Ramesses VI Corridor A

Ceiling from KV9.

H12 Tomb of Ramesses VI Corridor B

Ceiling from KV9.

H13 Tomb of Ramesses VI Hall E South Aisle

Ceiling from KV9.

H14 Tomb of Ramesses VI Hall E North Aisle

Ceiling from KV9.

H15 Tomb of Ramesses VII

Contains a pair of celestial diagrams, one in the southern half, one in the northern half of Hall B in KV1.

H16 Tomb of Ramesses IX

Contains a pair of celestial diagrams, one in the southern half, one in the northern half of Corridor B in KV6.

Description of the Sources

Chronologically, the sources span the period from 1480 to 1115 BC. H1 and H2 are from the XVIIIth dynasty, H3 to H8 from the XIXth dynasty, and H9 to H16 date from the XXth dynasty. Each celestial diagram contains a number of elements, as shown in Table 45.

We have already mentioned that certain celestial diagrams have layouts which are obviously related, and traced the connection between H11, H12, H13, H14, H15, and H16 in Figure 5. These sources share common features: they each form or contain pairs of celestial diagrams, (H11 with H12, and H13 with H14) each pair having the same two distinct decan lists, the same two arrangements of the circumpolar group, and an associated set of Ramesside star clock tables.

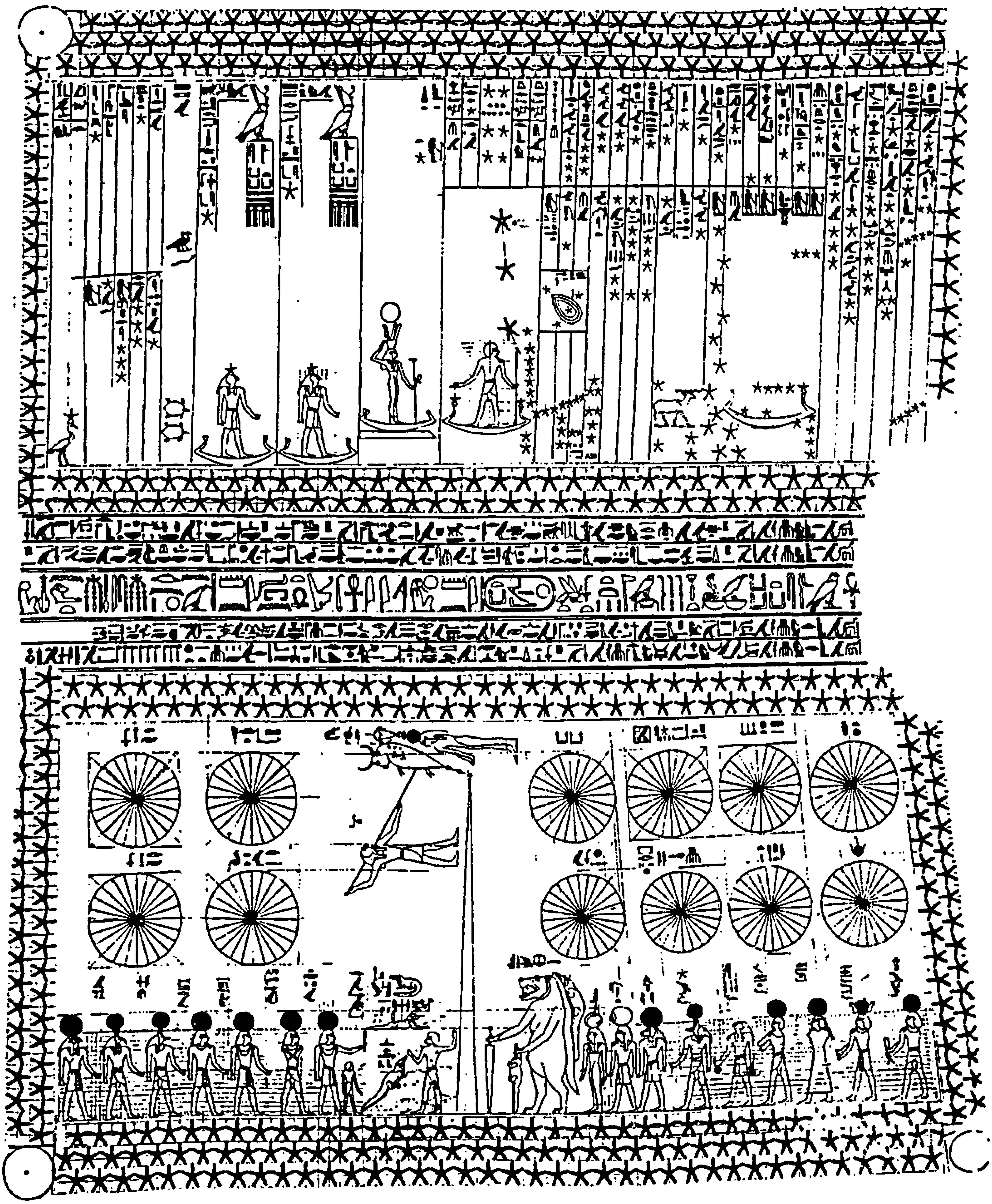

Figure 31: Ceiling from the tomb of Senmut
(from Dorman *The tombs of Senenmut*)

Similarly, it has been proved[187] that H9 was copied directly from H5. It is also likely that the other celestial diagram from Medinet Habu (H10) which has survived only on a loose block was similar in layout to the surviving pair. It is possible that there was another similar diagram on the ceiling of the Third Hypostyle hall in the Ramesseum that would also have belonged to this group.[188] The earliest example of this type of celestial diagram layout occurs as the decoration of the exterior of the Karnak water-clock (H2).[189]

Source	Circumpolar group	Circumpolar deities	Decans	Lunar Months	Ramesside star clock tables
H1 Tomb of Senmut	✓	✓	✓	✓	
H2 Karnak Water-clock	✓	✓	✓	✓	
H3 Tomb of Seti I	✓	✓	✓		
H4 Temple of Seti I at Abydos	[✓]	✓	✓		
H5 Ramesseum	✓	✓	✓	✓	
H6 Temple of Ramesses II at Abydos	✓	✓	✓		
H7 Tomb of Merneptah	✓	✓	✓		
H8 Tomb of Tausret Two Similar Ceilings	✓	✓	✓		
H9 Medinet Habu Ceiling I	✓	✓	✓	✓	
H10 Medinet Habu Ceiling II	✓	✓	✓	✓	
H11 Tomb of Ramesses VI Corridor A	✓	✓	✓		✓
H12 Tomb of Ramesses VI Corridor B	✓	✓	✓		✓
H13 Tomb of Ramesses VI Hall E South Aisle	✓	✓	✓		✓
H14 Tomb of Ramesses VI Hall E North Aisle	✓	✓	✓		✓
H15 Tomb of Ramesses VII	✓	✓	✓		✓
H16 Tomb of Ramesses IX	✓	✓	✓		✓

Table 45: Summary of elements contained within celestial diagrams

On the grounds of layout alone, H3, H7, and H8 form a group, as do H4 and H6. We

[187] Nims *Ramesseum sources of Medinet Habu reliefs* pp. 169-175.
[188] *Egyptian Astronomical Texts* 3 p. 20.
[189] The Ramesseum ceiling (H6) shows a baboon sitting on a djed-pillar in the centre of the lower register. Parker (*Calendars* p. 43) states that this layout (which can be restored in the diagrams from Medinet Habu (H9 and H10) and on the Karnak water-clock (H2) is a schematic representation of the lunar calendar with an intercalary month 'Thoth' represented by the baboon figure. The ceiling of Senmut (H1) does not include the baboon figure, but shows twelve 'wheels' that are usually accepted to represent twelve lunar months. Clagett (*Calendars, Clocks, and Astronomy* p. 22) states that Parker's assertions concerning the intercalary lunar calendar and its inclusion in these five sources (including that Sirius was used as a marker for intercalation) are unproved and untenable.

therefore have, after very cursory examination of the sources, five groups[190] of celestial diagrams (including two groups for the ceilings H11 to H16 which contain two distinct celestial diagrams). The ceiling of Senmut (H1) alone seems to have no immediate parallel. The purpose of placing the diagrams into groups is to facilitate analysis and comparison of the sources. Table 46 summarises and labels the groups.

Group A	Group B	Group C	Group D	Group E
H2	H3	H4	H11	H12
H5	H7	H6	H13	H14
H9	H8		H15 (South)	H15 (North)
H10			H16 (South)	H16 (North)
2nd Ramesseum ceiling?				

Table 46: Celestial diagrams grouped by layout

The Circumpolar Group

The circumpolar group is a recurring element in all groups.[191] It consists of a collection of figures representing those stars which always remain above the horizon.[192] In addition to the main figures of *Foreleg (Mes)*, *Hippo*, *Mooring Posts*, *Lion*, and the hawk-headed figure labelled *An* which are always present, Neugebauer and Parker identify the human or animal figures *Serket*, *Croc*, and *Sak* (who are given legends in some sources) and *Man*, *Bird*, and

[190] The ceiling of the tomb of Tharwas (No 232 at Dra' Abu el-Naga) dating from the XIXth or the XXth dynasty, contains a fragment of a celestial diagram of a layout different from any other sited in the list of sources, with the figures' feet in at least one of the three registers towards the middle of the ceiling. (*Egyptian Astronomical Texts* 3 pp. 24-26, fig. 4.)

[191] Zinner's early survey of circumpolar groups ('Die Sternbilder der alten Aegypter') includes reference to two of the IXth-Xth dynasty coffin lids (A1 and A3) due to his inability to identify such coffin lids as a different type of text. His reference to a 'circumpolar group' in these sources is due to the appearance of the Foreleg in the vertical strip.

[192] Some attempts at identifying the stars used in the Egyptian circumpolar group have been published: Wainwright ('A pair of constellations') identifies An with Cygnus; Bull ('An Ancient Egyptian astronomical ceiling') notes the resemblance between the bull and Hippo and Ursa Major. Biegel (*Zur Astrognosie*) makes extensive identifications as does Locher ('Probable Identification of the Ancient Egyptian Circumpolar Constellations'). None of these theories has gained any degree of general acceptance, with all being generally ignored except Biegel's which has been criticised by Pogo ('Zum Problem der Identifikation') and Neugebauer and Parker (*Egyptian Astronomical Texts* 3 p. 183 fn. 2). Davis ('Identifying Egyptian Constellations') also outlined a system of identifications of not only the circumpolar stars but also certain other decanal constellations, but her conclusions are equally unsubstantiated.

Second Man[193] (who are never given names).[194]

In the ceiling of Senmut, *Bird* and *Second Man* are omitted. In Group A wherever the circumpolar group remains, we find that *Man, Bird,* and *Second Man* are omitted. Group B seems to omit only *Sak*. Very little of a circumpolar group is preserved in H6 of Group C but *Serket, Lion,* and a teardrop-shaped *Foreleg* are visible. The sources of Group D contain all the figures except *Second Man*, while Group E omits *Sak, Serket,* and *Bird,* but includes a *Second Man*.

A distinction can also be made between representations of *Foreleg*. Groups A, C, E, and Senmut all show *Foreleg* as a 'teardrop' shape, while Group B and D sources have a complete ox.[195]

Table 47 summarises these attributes of the circumpolar groups.

	Serket	Sak	Croc	Man	Bird	Man 2	Foreleg Shape
H1 Senmut	✓	✓	✓	✓			Teardrop
Group A	✓	✓	✓				Teardrop
Group B	✓		✓	✓	✓	✓	Ox
Group C	✓	?	?	?	?	?	Teardrop
Group D	✓	✓	✓	✓	✓		Ox
Group E			✓	✓		✓	Teardrop

Table 47: Composition of the circumpolar group in celestial diagrams

Of the constituent figures of the circumpolar group, the *Book of the Day* passage examined in Section G explains the mythology behind certain figures. The Hippo, Mooring Posts, and

[193] In their list on pp. 183-184 of *Egyptian Astronomical Texts* 3, Neugebauer and Parker list one type of Man with two possible positions. In the four sources of Group D, one type of circumpolar group has two men, but Neugebauer and Parker say that the second is there mistakenly instead of Serket. H3 has *Serket* in addition to both types of Man, proving that the two men are distinct.

[194] Isler 'An Ancient Method of Finding and Extending Direction' postulates that an additional feature of the circumpolar group holds significance: the vertical pole, spike, or spear. This assertion stems from his belief that both gnomons and stars were instrumental in finding north. He particularly cites the vertical line in the circumpolar group from the southern half of the ceiling of Ramesses VII which appears to form the spear used by the god An (whom he incorrectly labels as Horus) and the vertical spike in the circumpolar group in the ceiling of Senmut (which Pogo 'Astronomical Ceiling-decoration in the Tomb of Senmut' was the first to believe held directional significance). Wilkinson 'New Kingdom astronomical paintings' disputes Isler's findings concerning the solar significance of the circumpolar group, but agrees that a pole could have some use for stellar observation.

[195] Tharwas has preserved part of *Hippo, An,* and *Foreleg*.

Foreleg, together with the chain that is sometimes depicted as linking two or more figures, are explicitly mentioned. The surrounding 'Water-of-the-Gods' either relates to the area immediately adjacent to the circumpolar region or to the horizon area. In either case, we could possibly imagine a wet region designed to contain the Foreleg and its guardian. The natural choice of inhabitants for such a region with such a purpose would be crocodiles. This is a possible explanation for the assortment of this type of creature which appears in the various depictions of the circumpolar group. The nature or purpose of the other figures is unknown.[196]

Decan Lists

Complete lists or fragments of lists are present in all the celestial diagrams. Unlike the occurrences of the decans in the context of star clocks, the decans in a celestial diagram are accompanied by deities and numbers of stars or circles.

Neugebauer and Parker compared and analysed extensively the decan lists contained within the New Kingdom sources labelled 2 to 29 in *Egyptian Astronomical Texts* 3. Table 48 shows which decans appear in each of the celestial diagrams dealt with in this chapter. The numbers in brackets refer to Neugebauer and Parker's classification of the sources, and at the base of each column, a label shows to which family of decans Neugebauer and Parker considered each source to belong.

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[196] The use of figures, birds, animals, and objects to depict constellations is a familiar concept. We know that very few of our own constellations form shapes that even vaguely represent the object after which they are named. However, it is tempting to search for similarities between the figures of the Egyptian constellations and arrangements of stars. In particular, the obvious correlation between the Foreleg and the shape of The Plough, and the imagineable similarity between our Orion pattern and the Egyptian Sahu figure (in particular the depiction of the three large stars resembling Orion's belt in the ceiling of Senmut) leads us to suppose that the motivation behind at least some of the constellation names could be traceable. It has already been noted that other researchers have pursued this approach (see footnotes 1 and 192). Three examples are Wells ('Sothis and the Satet temple') who links our constellation Scorpius to a representation of a scorpion and an encircled star in the temple; Beaux 'Sirius Étoile et Jeune Horus' who suggests that the name and some attributes of *spdt* could arise from the triangle shape formed by Sirius, Rigel, and Betelgeuse; and Bradshaw *The Imperishable Stars* who suggests (as part of a theory which is highly suppositional) the interesting idea that constellations could have different attributes and hence different figures depending on their orientation in the sky as they rotate around the north celestial pole.

Teardrop-shaped Foreleg										Bull-shaped Foreleg					
Senmut	A			E				C		B		D			
H1 Senmut	H2 Karnak	H5 Ramesseum	H9 Medinet Habu	H12 Ramesses VII	H14 Ramesses VI	H15 (North) Ramesses VII	H16 (North) Ramesses IX	H4 Seti I	H6 Ramesses II	H3 Seti I	H8 Tausert	H11 Ramesses VI	H13 Ramesses VI	H15 (South) Ramesses VII	H16 (South) Ramesses IX
tpy-ʿ knmt	*tpy-ʿ knmt*	*tpy-ʿ knmt*	*tpy-ʿ knmt*		*tpy-ʿ knmt*	*tpy-ʿ knmt*				*tpy-ʿ knmt*			*tpy-ʿ knmt*	*tpy-ʿ knmt*	*tpy-ʿ knmt*
knmt	*knmt*	*knmt*	*knmt*		*knmt*					*knmt*			*knmt*	*knmt*	*knmt*
ḥry ḫpd knmt	*ḥry ḫpd knmt*	*ḥry ḫpd knmt*	*ḥry ḫpd knmt*		*ḥry ḫpd knmt*					*ḥry ḫpd knmt*			*ḥry ḫpd knmt*	*ḥry ḫpd knmt*	*ḥry ḫpd knmt*
ḥ3t ḏ3t	*ḥ3t ḏ3t*	*ḥ3t ḏ3t*	*ḥ3t ḏ3t*		*ḥ3t ḏ3t*		*ḥ3t ḏ3t*			*ḥ3t ḏ3t*			*ḥ3t ḏ3t*	*ḥ3t ḏ3t*	*ḥ3t ḏ3t*
pḥwy ḏ3t	*pḥwy ḏ3t*	*pḥwy ḏ3t*	*pḥwy ḏ3t*		*pḥwy ḏ3t*		*pḥwy ḏ3t*			*pḥwy ḏ3t*			*pḥwy ḏ3t*	*pḥwy ḏ3t*	*pḥwy ḏ3t*
ṯm3t ḥrt	*ṯm3t ḥrt*	*ṯm3t ḥrt*	*ṯm3t ḥrt*		*ṯm3t ḥrt*	*ṯm3t ḥrt*	*ṯm3t ḥrt*			*ṯm3t ḥrt*			*tm3t ḥrt*	*tm3t ḥrt*	*tm3t ḥrt*
ṯm3t ẖrt	*ṯm3t ẖrt*	*ṯm3t ẖrt*	*ṯm3t ẖrt*		*ṯm3t ẖrt*	*ṯm3t ẖrt*	*ṯm3t ẖrt*	*ṯm3t ẖrt*		*ṯm3t ẖrt*			*tm3t ẖrt*	*tm3t ẖrt*	*tm3t ẖrt*
wš3ti	*wš3ti*	*wš3ti*	*wš3ti*		*wš3ti*	*wš3ti*	*wš3ti*	*wš3ty*		*wš3ti*		*wš3ti*	*wš3ty bk3ty*	*wš3ty bk3ty*	*wš3ty bk3ty*
bk3ti	*bk3ti*	*bk3ti*	*bk3ti*		*bk3ti*		*bk3ti*	*bk3ty*		*bk3ti*			*sb3w mḥw*	*sb3w mḥw*	*sb3w mḥw*
tpy-ʿ ḫntt	*tpy-ʿ ḫntt*	*tpy-ʿ ḫntt*	*tpy-ʿ ḫntt*		*tpy-ʿ ḫntt*		*tpy-ʿ ḫntt*	*tpy-ʿ ḫntt*		*tpy-ʿ ḫntt*			*tpy-ʿ ḫntt*	*tpy-ʿ ḫntt*	*tpy-ʿ ḫntt*
ḫntt ḥrt	*ḫntt ḥrt*	*ḫntt ḥrt*	*ḫntt ḥrt*		*ḫntt ḥrt*	*ḫntt ḥrt*	*ḫntt ḥrt*	*ḫntt ḥrt*		*ḫntt ḥrt*			*ḫntt ḥrt*		*ḫntt ḥrt*
ḫntt ẖrt	*ḫntt ẖrt*	*ḫntt ẖrt*	*ḫntt ẖrt*		*ḫntt ẖrt*	*ḫntt ẖrt*	*ḫntt ẖrt*	*ḫntt ẖrt*	*ḫntt ẖrt*	*ḫntt ẖrt*			*ḫntt ẖrt*	*ḫntt ẖrt*	*ḫntt ẖrt*
ṯms n ḫntt	*ṯms n ḫntt*	*ṯms n ḫntt*	*ṯms n ḫntt*	*ṯms n ḫntt*	*ṯms n ḫntt*	*ṯms n ḫntt*	*ṯms n ḫntt*		*ṯms n ḫntt*	*ṯms n ḫntt*			*ṯms n ḫntt*	*ṯms n ḫntt*	*ṯms n ḫntt*
s3pti ḫnwy	*s3pti ḫnwy*	*s3pti ḫnwy*	*s3pti ḫnwy*		*s3pti ḫnwy*	*s3pti ḫnwy*	*s3pti ḫnwy*		*s3pti ḫnwy*	*s3pti ḫnwy*			*s3pti ḫnwy*		*s3pti ḫnwy*
ḥry-ib wi3	*ḥry-ib wi3*	*ḥry-ib wi3*	*ḥry-ib wi3*		*ḥry-ib wi3*	*ḥry-ib wi3*	*ḥry-ib wi3*		*ḥry-ib wi3*	*ḥry-ib wi3*			*ḥry-ib wi3*	*ḥry-ib wi3*	*ḥry-ib wi3*
sšmw		*sšmw*	*sšmw*		*sšmw*	*sšmw*	*sšmw*		*šsmw*	*šsmw*			*šsmw*	*šsmw*	*šsmw*
knmw	*knmw*	*knmw*	*knmw*		*knmw*	*knmw*	*knmw*		*knmw*	*knmw*	*knmw*		*knmw*	*knmw*	*knmw*
tpy-ʿ smd	*tpy-ʿ smd*	*tpy-ʿ smd*	*tpy-ʿ smd*		*tpy-ʿ smd*	*tpy-ʿ smd*	*tpy-ʿ smd*		*tpy-ʿ smd*	*tpy-ʿ smd*	*tpy-ʿ smd*		*tpy-ʿ smd*	*tpy-ʿ smd*	*tpy-ʿ smd*
smd	*smd*	*smd*	*smd*		*smd*		*smd*		*smd*	*smd*	*smd*		*smd*	*smd*	*smd*
sit	*sit*	*sit*	*sit*		*sit*		*sit*		*srt*	*srt*	*srt*		*srt*	*srt*	*srt*
s3wy sit	*s3wy sit*	*s3wy sit*			*s3wy srt*		*s3wy sit*		*s3wy srt*	*s3wy srt*	*s3wy srt*		*s3wy srt*	*s3wy srt*	*s3wy srt*
ḥry ḫpd srt	*ḥry ḫpd srt*	*ḥry ḫpd srt*	*ḥry ḫpd srt*		*ḥry ḫpd srt*	*ḥry ḫpd srt*	*ḥry ḫpd srt*		*ḥry ḫpd srt*	*ḥry ḫpd srt*	*ḥry ḫpd srt*		*ḥry ḫpd srt*	*ḥry ḫpd srt*	*ḥry ḫpd srt*
tpy-ʿ 3ḫ(wy)	*tpy-ʿ 3ḫ(wy)*	*tpy-ʿ 3ḫ(wy)*	*tpy-ʿ 3ḫ(wy)*		*tpy-ʿ 3ḫwy*	*tpy-ʿ 3ḫwy*	*tpy-ʿ 3ḫ(wy)*		*tpy-ʿ 3ḫwy*	*tpy-ʿ 3ḫwy*	*tpy-ʿ 3ḫwy*		*tpy-ʿ 3ḫwy*	*tpy-ʿ 3ḫwy*	*tpy-ʿ 3ḫwy*
3ḫwy	*3ḫwy*	*3ḫwy*	*3ḫwy*							*3ḫwy*	*3ḫwy*		*3ḫwy*	*3ḫwy*	*3ḫwy*
b3wy	*b3wy*	*b3wy*	*b3wy*	*b3wy*	*b3wy*	*b3wy*				*b3wy*	*b3wy*		*b3wy*	*b3wy*	*b3wy*
ḫntw ḥr(w)	*ḫntw ḥr(w)*	*ḫntw ḥr(w)*	*ḫntw ḥr(w)*		*ḫntw ḥrt*	*ḫntw ḥrt*				*ḫntw ḥrw*	*ḫntw ḥrw*		*ḫnt(w) ḥrw*	*ḫnt(w) ḥrw*	*ḫnt(w) ḥrw*
(ḫntw) ẖrw	*(ḫntw) ẖrw*	*(ḫntw) ẖrw*	*(ḫntw) ẖrw*	*(ḫntw) ẖrw*	*ḫntw ẖrt*	*ḫntw ẖrt*				*ḥry-ib ḫntw*	*ḥry-ib ḫntw*		*ḥry-ib ḫnt(w)*	*ḥry-ib ḫnt(w)*	*ḥry-ib ḫnt(w)*
ḳd	*ḳd*	*ḳd*			*ḳd*					*ḫntw ẖrw*	*ḫntw ẖrw*		*ḫnt(w) ẖrw*	*ḫnt(w) ẖrw*	*ḫnt(w) ẖrw*
s3wy ḳd	*s3wy ḳd*	*s3wy ḳd*	*s3wy ḳd*		*s3wy ḳd*					*ḳd*	*ḳd*		*ḳd*	*ḳd*	*ḳd*
ḫ3w	*ḫ3w*	*ḫ3w*		*ḫ3w*	*ḫ3w*					*s3wy ḳd*	*s3wy ḳd*		*s3wy ḳd*	*s3wy ḳd*	
ʿrt	*ʿrt*	*ʿrt*	*ʿrt*	*ʿrt*	*ʿrt*	*ʿrt*			*ḫ3w*	*ḫ3w*	*ḫ3w*		*ḫ3w*	*ḫ3w*	
ḥry rmn s3ḥ	*ḥry rmn s3ḥ*	*ḥry rmn s3ḥ*	*ḥry rmn s3ḥ*		*ḥry rmn s3ḥ*	*ḥry rmn s3ḥ*			*ʿrt*	*ʿrt*	*ʿrt*		*ʿrt*		
ẖry rmn s3ḥ		*ẖry rmn s3ḥ*	*ẖry rmn s3ḥ*		*ẖry rmn s3ḥ*	*ẖry rmn s3ḥ*			*iwn s3ḥ*	*iwn s3ḥ*	*iwn s3ḥ*		*iwn s3ḥ*		
		rmn s3ḥ	*rmn s3ḥ*						*rmn ḥry*	*rmn ḥry*	*rmn ḥry*		*rmn ḥry s3ḥ*		
s3ḥ				*s3ḥ*	*s3ḥ*	*s3ḥ*			*msḏr s3ḥ*	*msḏr s3ḥ*	*msḏr s3ḥ*		*msḏr s3ḥ*		
spdt	*spdt*	*spdt*		*spdt*	*spdt*					*rmn ẖry s3ḥ*	*rmn ẖry s3ḥ*		*rmn ẖry s3ḥ*	*rmn ẖry s3ḥ*	
										ʿ s3ḥ	*ʿ s3ḥ*		*ʿ s3ḥ*	*ʿ s3ḥ*	
										s3ḥ	*s3ḥ*		*s3ḥ*	*s3ḥ*	
										spdt	*spdt*		*spdt*		*spdt*
														si3t	
ḥr-t3š-t3wy	*ḥr-t3š-t3wy*	*ḥr-t3š-t3wy*	*ḥr-t3š-t3wy*	*ḥr-t3š-t3wy*	*ḥr-t3š-t3wy*	*ḥr-t3š-t3wy*	*ḥr-t3š-t3wy*			*ḥr-t3š-t3wy*	*ḥr-t3š-t3wy*		*ḥr-wpš-t3wy*		*ḥr-wpš-t3wy*
ḥr-k3-pt	*ḥr-k3-pt*	*ḥr-k3-pt*		*ḥr-k3-pt*	*ḥr-k3-pt*	*ḥr-k3-pt*	*ḥr-k3-pt*			*ḥr-k3-pt*	*ḥr-k3-pt*		*ḥr-k3-pt*		*ḥr-k3-pt*
		ḥr-3ḫty		*ḥr-3ḫty*	*ḥr-3ḫty*	*ḥr-3ḫty*	*ḥr-3ḫty*			*ḥr-3ḫty*	*ḥr-3ḫty*		*ḥr-3ḫty*		*ḥr-3ḫty*
štwy	*štwy*	*štwy*			*štwy*	*štwy*				*štwy*	*štwy*		*štwy*		*štwy*
nsrw	*nsrw*	*nsrw*			*nsrw*	*nsrw*				*nsrw*	*nsrw*		*si3tw*		*si3tw*
šspt	*šspt*	*šspt*			*šspt*	*šspt*				*šspt*	*šspt*		*nsrw*	*nsrw*	
ipds	*ipds*	*ipds*		*ipds*	*ipds*	*ipds*				*ipḏs*	*ipḏs*		*šspt*	*šspt*	
sbššn	*sbššn*	*sbššn*			*sbššn*	*sbššn*	*sbššn*			*sbššn*	*sbššn*		*nhs*	*nhs*	
nṯr w3s	*nṯr w3s*	*nṯr w3s*			*nṯr w3š*	*nṯr w3š*	*nṯr w3š*			*nṯr w3š*	*nṯr w3š*		*sbššn*		
													nṯr w3š		*nṯr w3š*
sbg	*sbg*	*sbg*		*sbg*	*sbg*	*sbg*	*sbg*			*sbgw*	*sbgw*		*sbg*		*sbg*
ḏ3	*ḏ3*	*ḏ3*			*ḏ3*	*ḏ3*	*ḏ3*			*sb3-ḏ3*	*sb3-ḏ3*		*ḏ3*		*ḏ3*

Shading = lost Hatching = omitted entirely, never there

Table 48: Decan lists from New Kingdom astronomical diagrams

The body of the table is divided horizontally into four parts. The first part contains the main decan list, the second the three superior planets, the third triangle decans, and the fourth the two inferior planets. Hatching indicates portions which never existed in the source, while shading represents information that has been lost.

Concerning the planets, the ceiling of Senmut and the Karnak water-clock omit Mars, as do the other members of Neugebauer and Parker's 'Senmut Main Group'. In all other cases, it is fair to assume that all five planets were intended to be present.

We know from our discussion of diagonal star clocks in Part I that we would expect triangle decans to appear in a complete list. The most complete triangle list in a celestial diagram occurs in H12, the southern half of the ceiling of Hall E in the tomb of Ramesses VI, where seven triangle decans are shown. We also see that all the triangle decans which occur in the other sources are members of this group with the exception of one additional name, *ỉpḏs*, which occurs in the triangle lists from other celestial diagrams.

We therefore have the following fragmentary triangle list:

štwy
sỉ3tw
nsrw
sšpt
nhs
ỉpḏs
sbšsn
nṯr w3š

In the discussion of the diagonal star clocks, we saw that the composition of the triangle decans was difficult to reconstruct due to the confusion that was seen in this area of the star clock tables. Neugebauer and Parker provided a list of triangle decans labelled A to M (omitting I) which are shown in Table 19.[197] We can see immediately that none of the triangle decans from the celestial diagrams appears in this list.

[197] The similarly named pairs were distinguished by their writings, and the list is based primarily on that of source A1, with the triangle decan *s3bw* being added by the epagomenal lists of A6 and A8.

Three decans from the lists Θ and Φ appear in the triangle decan lists from the celestial diagrams: *ìpḏs* is the ninth decan 9 of Θ, *sbšsn* is the tenth decan of Θ, and *sšpt* is the tenth decan in Φ.

Neugebauer and Parker noted that the decan list in H1, the ceiling of Senmut, corresponded to the order of a diagonal star clock table starting with the decan *tpy-ʿ knmt* as decan of the first hour of I Akhet 1, continuing with the decans in the order they appeared on that date, and then with the decans of the twelfth hour of the night for each of the subsequent ten-day periods.[198] This provides a list of thirty-six ordinary decans which should then be followed by eleven triangle decans. If the principle was extended to include the twelfth hour in the epagomenal column, the twelfth triangle decan would be added to the end of the list. However, H1 includes only six triangle decans.[199]

Tpy-ʿ knmt was also the decan for the first hour of I Akhet 1 in the group of star clock tables containing the list Φ. We must therefore assess how closely Φ (Table 22) relates to the decan list of H1 (first column of Table 48). The correlation is very clear. The inclusion in the synthesised list Φ of the decan *sšpt* is the only major difference between the two lists up to the area of confusion around the Orion decans.

If Neugebauer and Parker's theory of the origin of the decan order in H1 is accepted, the resemblance between Φ and the decan list of H1 implies a proximity in date and place of construction for the two lists. The omission of *sšpt* in H1 may imply either that we were wrong to include it in Φ, meaning that the decan must be an out of order triangle decan in sources A11, A13, and A14, or that *sšpt* was included or omitted in a minor adjustment of

198 *Egyptian Astronomical Texts* 1 p. 22 but also note *Egyptian Astronomical Texts* 3 p. 272 'Additions and Corrections to Volume 1' where due to their revised idea of the composition and order of the Orion decans, *štw(y)* becomes the first triangle decan rather than the last ordinary decan as stated in *Egyptian Astronomical Texts* 1.

199 *Egyptian Astronomical Texts* 3 p. 118.

the decan list at some time.

As was noted earlier, no triangle decans belonging to Φ have survived in their correct positions, so identification of any triangle decans with certainty is impossible. The relationship between the ordinary decans of H1 and Φ would lead us to believe that the triangle list of Φ could be restored from the triangle list of H1. Initially, this approach seems to strengthen Neugebauer and Parker's assertion that *sšpt* is an out of place triangle decan in A11, despite the additional occurrence of the decan among the ordinary decans in the orderly A13 and A14, due to the inclusion of *sšpt* in the triangle list of H1.

However, we can check the assumption that H1 can supply possible triangle decans for Φ by noting that the triangle decans should occur in the same area of the sky as the first twelve ordinary decans in a list. The triangle decans of Φ should therefore contain decans in the region around *knmt* to *ḫntt ḫrt*. Similarly, the triangle of Θ which has *ṯmȝt ḫrt* as the first hour of the night in I Akhet 1 would have triangle decans in the same region as the decans *ṯmȝt ḫrt* to 'crew'. We see immediately that there are problems (Table 49).

Θ assumed region of triangle	Triangle from A1 etc. which should relate to Θ	Φ assumed region of triangle	Celestial diagrams triangle
ṯmȝt ḫrt	*smd rsy*	*tpy-ʿ knmt*	*štwy*
ṯmȝt ḫrt	*smd mḥty*	*knmt*	*sȝtw*
wšt bkȝt	*nṯr dȝ pt*	*ḥry ḫpd n knmt*	*nsrw*
ipds	*rmn ḥry*	*ḥȝt dȝt*	*sšpt*
sbšsn	*ḫȝw*	*pḥwy dȝt*	*nhs*
ḫntt ḫrt	*tpy-ʿ spd*	*ṯmȝt ḫrt*	*ipds*
ḫntt ḫrt	*imy-ḫt spd*	*ṯmȝt ḫrt*	*sbšsn*
ṯms n ḫntt	*ȝḫwy*	*wšȝti*	*nṯr wȝš*
ḳdty	*ḫȝw*	*bkȝti*	
"*ḫnwy*"	*nṯr dȝ pt*	*sšpt*	
ḥry-ib wiȝ	*sȝbw*	*tpy-ʿ ḫntt*	
"*crew*"	*pḥwy sȝbw*	*ḫntt ḫrt*	

Table 49: Triangle lists from star clocks and celestial diagrams

The decans of the triangle associated with Θ seem to be gathered from the region of the sheep, the spirits, *ḫȝw*, *sȝḥ*, and *spdt* (14-31 if *ṯmȝt ḫrt* is counted as decan 1). This implies that a later 'sheep' decan (*ḥry ḫpd srt* is the last 'sheep' member of Θ) marked the first hour of the night in the first decade of the year – an occurrence which would happen to *ḥry ḫpd srt* in *n* - 640. We saw earlier that *n* is between 2150 and 2020 BC so the date of the triangle of Θ is between 2790 BC and 2660 BC.[200,201] The triangle at that date would be in the region:

ḥry ḫpd srt
tpy-ʿ ȝḫwy
imy-ḫt ȝḫwy
ȝḫwy
bȝwy
ḳd
ḫȝw
ʿrt
ḥry ʿrt
rmn ḥry
rmn ḥry
ȝbwt
ḥrt wʿrt
tpy-ʿ spd

which is acceptable when compared with the composition that survives in sources A1, A6, A7, and A8.

The triangle decans from the celestial diagrams, however, contain *ipḏs* and *sbšsn* (which are from the same region of the sky from which we expected the Θ triangle decans to come) as well as *sšpt*, which we proposed was an ordinary decan of Φ between *bkȝti* and *tpy-ʿ ḫntt*. In terms of Θ, this would place *sšpt* somewhere between *wšt bkȝt* and *ḫntt ḥrt*. These three triangle decans are the only ones we can relate with certainty to ordinary decans in Θ and Φ.

200 Neugebauer and Parker reasoned along similar lines using *imy-ḫt spd* to find a date earlier than 2780 BC.
201 McKim Malville et al in 'Megaliths and Neolithic astronomy in southern Egypt' publish evidence of astronomical alignment in a stone circle near Nabta. The group who constructed the circle were present in the Nabta Playa depression from around 10,000 years BP (before the present) until climatic change caused 'an exodus from the Nubian desert ~ 4,800 years BP [which] may have stimulated social differentiation and cultural complexity in pre-dynastic Upper Egypt'. We therefore have an influx of astronomically knowledgeable people with some kind of observational tradition arriving in the lower Nile valley at around the same time that we have the earliest evidence of development of timekeeping decan lists.

Their closeness in position and the defective nature of the celestial diagrams' triangle list do not allow us to determine to which, if either, of the two lists Θ or Φ the triangle lists correspond, although the date of the diagrams' triangle list must be close to Θ and Φ.

Summarising, we have three surviving types of decan list:

early diagonal star clock tables:	year ~ *n* main list, *n - 640* or earlier triangle
later diagonal star clock tables:	year ~ *n + 160* or *200* main list, no preserved triangle
celestial diagrams:	year ~ *n + 160* or *200* main list, circa *n* to *n + 200* triangle

From this summary, we can see that although the decans were used in celestial diagrams in the New Kingdom, there is no surviving evidence to suggest that the lists were still being updated at that period.[202]

The ordinary decans contained within the celestial diagrams and shown in Table 48 in the top section will now be discussed. H7 and H10 have no decan names preserved, but from figures, and including the deities which accompany the decans in the celestial diagrams, Neugebauer and Parker placed the decan lists in these fourteen sources into five groups (indicated in the lowest row of Table 48): the Senmut Main Group and Subgroups A and B, the Seti I C group, and Subgroup A of the Seti I A group.

Considering for the moment the names of the decans only, Table 48 shows us that sources H1, H2, H5, and H9 (Senmut and Group A) have essentially the same decan list as the lists of H11, H12, H13, and H14 which are accompanied by a circumpolar group containing a

[202] We therefore have evidence for adjustment or creation of decan lists from around 2790 – 2220 BC. Looking at decan lists contained within monuments from after the New Kingdom, Neugebauer and Parker identified nine which conform to the 'Senmut' type (i.e. are included in their Senmut Main Group), two which resembled the α and Group D lists (Petosiris and Nekhtnebef), ten lists forming a group into which Neugebauer and Parker placed list β (we have rejected this association, thus leaving a group composed entirely of post-New Kingdom decan lists), a group of ten lists from the Greco-Roman Period and four fragmentary 'Miscellaneous' lists. In none of these last three groups can any triangle decans be identified with certainty, and the variation in choice of first decan among the lists allows no analysis of the date of construction of any of the lists, nor determination of whether any list was adjusted for any timekeeping purpose or was even created with that goal.

teardrop-shaped *Foreleg* (Group D Part 2). These are the lists from Neugebauer and Parker's 'Senmut family' of decan lists. Also, H3 and H8 (Group B) have essentially the same decan lists as Group D Part 1, which are from the 'Seti I C' and 'Seti I A Subgroup A' families.

Across all the lists where decans are preserved, we see that each begins with *tpy-ʿ knmt*. Barring individual omissions, there seems to be a consensus that *ḫntw ḥrw* is the twenty-sixth decan. This unity is achieved in the lists (H13, H15 (South), and H16 (South) of Group D) which join *wš3ti* and *bk3ti* into one decan *wš3ti bk3ti*, by the insertion of a new decan *sb3w mḥw*. After *ḫntw ḥrw*, there is confusion in the area of *s3ḥ* resulting in lists shorter than thirty-six decans in the Senmut families and longer than thirty-six decans in the other families.

Neugebauer and Parker place H4 and H6, the two lists from the Abydos temples, as part of the 'Seti I C' family with H3 and H8 due to the writing of certain decan names. However, the circumpolar group which is thought to belong to H6 has a teardrop-shaped *Foreleg* similar to those accompanying the 'Senmut' family lists.

Neugebauer and Parker also considered the number of stars or star circles appearing with the decanal names, the writing of the names,[203] and the deities associated with each decan as factors when grouping the decan lists. As they note, the number of stars assigned to a particular decan varies between groups, allowing no opportunity for this information to be used as a method of identifying the stars involved.[204] The introduction of such additional information as numbers of stars and deities is indicative of some underlying processes of which we are currently unaware. In the case of the number of stars, we can easily imagine

[203] Full details of the writing of decanal names can be found in *Egyptian Astronomical Texts* 1 for decans used in diagonal star clocks and *Egyptian Astronomical Texts* 3 for those employed in celestial diagrams. The section of *Egyptian Astronomical Texts* 3 which describes each decan list 'group' also contains full details of the number of star symbols associated with each decan, as well as the decanal deities.
[204] *Egyptian Astronomical Texts* 3 p. 2.

this to be based on a practical method of improving decan recognition by indicating the number of stars in the decanal group. This implies a development of observational practice for which we have no other evidence, but which we accept is a logical aide to naked-eye astronomy. The difference in the number of star symbols between decan list traditions is an indication that the process of deciding how many stars belonged to each decan was probably subject to human factors such as varying eyesight, personal preference, and tradition. The area is further confused by the practise of sharing stars between decans and other graphical considerations.

Decanal deities present a more difficult concept. It is an Egyptian habit to have not only lists of names of objects, but also a deity assigned to each member of the list. For example the Coptic names for Egyptian months derive from both the names of months and the names of deities. The one-to-one assignment of deities to list members is usual and the practice was widespread throughout Egyptian religious thought. It is therefore highly unusual, and seemingly very significant, that the deities assigned to decans within a single list do not conform to this one-to-one system. Deities of decans for celestial diagrams in Groups A to E are shown in Table 50. The most common decanal deities are the four Children of Horus, Duamutef, Kebehsenuf, Hapy, and Imseti, assigned either individually, in pairs, or as a group of four. Where the Children occur in pairs, Imseti only occurs with Hapy. Duamutef is the most common Child. Apart from the Children, other decanal deities include Geb, Isis, Osiris, Nephthys, Seth (sometimes written *wš*), and Horus from the Ennead, Eye or Eyes of Horus, Hathor, Sekhmet, and 'Ba'. Of these, Geb, Sekhmet, Hathor, and Ba are limited to four of the first five decans in lists belonging to Groups B, C, and E. Osiris is exclusively linked with Orion decans while Isis, although associated with *spdt* as we would expect, is also the deity for certain other decans.

	Group D		Group A, H1	Group E		Groups B and C
Decans	Deities	Decans	Deities	Deities	Decans	Deities
tpy-ꜥ knmt	Hapy, Imseti	*tpy-ꜥ knmt*	Hapy, Imseti	Geb	*tpy-ꜥ knmt*	Geb
knmt	Isis	*knmt*	Isis	Ba	*knmt*	Ba
ẖry ḫpd knmt	Children of Horus	*ẖry ḫpd knmt*		Sekhmet	*ẖry ḫpd knmt*	Sekhmet
ḥꜣt ḏꜣt	Children of Horus	*ḥꜣt ḏꜣt*	Duamutef	Isis	*ḥꜣt ḏꜣt*	Isis
pḥwy ḏꜣt	Children of Horus	*pḥwy ḏꜣt*	Children of Horus	Hathor	*pḥwy ḏꜣt*	Hathor
tmꜣt ḥrt	Children of Horus	*ṯmꜣt ḥrt*	Duamutef	Children of Horus	*ṯmꜣt ḥrt*	Imseti, Hapy
tmꜣt ẖrt	Duamutef	*ṯmꜣt ẖrt*		Children of Horus	*ṯmꜣt ẖrt*	Kebehsenuf
wšꜣty bkꜣty	Duamutef	*wšꜣti*	Duamutef	Duamutef, Kebehsenuf	*wšꜣty*	Duamutef
sbꜣw mḥw	Duamutef	*bkꜣti*	Hapy	Duamutef, Kebehsenuf	*bkꜣty*	Duamutef, Kebehsenuf
tpy-ꜥ ḫntt	Duamutef, Hapy	*tpy-ꜥ ḫntt*	Horus	Hapy, Duamutef	*tpy-ꜥ ḫntt*	Duamutef, Hapy
ḫntt ḥrt	Horus	*ḫntt ḥrt*		Horus	*ḫntt ḥrt*	Horus
ḫntt ẖrt	(*wš*)	*ḫntt ẖrt*	Set	Set	*ḫntt ẖrt*	Set
ṯms n ḫntt	*wš*	*ṯms n ḫntt*	Horus	Horus	*ṯms n ḫntt*	Horus
sꜣpti ḫnwy	Isis, Nephthys	*sꜣpti ḫnwy*	Isis, Nephthys	Isis, Nephthys	*sꜣpti ḫnwy*	Isis, Nephthys
ḥry-ib wiꜣ	*wš*	*ḥry-ib wiꜣ*	Set	*wš*	*ḥry-ib wiꜣ*	Set
šsmw	*wš*	*sšmw*	Set	*wš*	*šsmw*	Horus
knmw	Children of Horus	*knmw*	Children of Horus	Children of Horus	*knmw*	Imseti, Hapy, Duamutef, Kebehsenuf
tpy-ꜥ smd	Horus	*tpy-ꜥ smd*	Horus	Horus	*tpy-ꜥ smd*	Horus
smd	Hapy	*smd*	Hapy	Hapy	*smd*	Hapy
srt	Isis	*sit*	Isis	Isis	*srt*	Isis
sꜣwy srt	Duamutef	*sꜣwy sit*	Duamutef	Duamutef, Kebehsenuf	*sꜣwy srt*	Duamutef, Kebehsenuf
ẖry ḫpd srt	Kebehsenuf	*ẖry ḫpd srt*	Kebehsenuf	Kebehsenuf	*ẖry ḫpd srt*	Kebehsenuf
tpy-ꜥ ꜣḫwy	Duamutef	*tpy-ꜥ ꜣḫ(wy)*	Duamutef	Duamutef, Kebehsenuf	*tpy-ꜥ ꜣḫwy*	Duamutef, Kebehsenuf
ꜣḫwy	Duamutef, Kebehsenuf	*ꜣḫwy*	Duamutef, Kebehsenuf	Duamutef, Kebehsenuf	*ꜣḫwy*	Duamutef, Kebehsenuf
bꜣwy	Imseti, Hapy	*bꜣwy*	Hapy, Imseti	Hapy, Imseti	*bꜣwy*	Imseti, Hapy
ḫnt(w) ḥrw	Horus	*ḫntw ḥr(w)*	Children of Horus	Horus	*ḫnt(w) ḥrw*	Horus
ḥry-ib ḫnt(w)	Horus				*ḥry-ib ḫnt(w)*	Horus
ḫnt(w) ẖrw	Horus	(*ḫntw*) *ẖrw*		Horus	*ḫnt(w) ẖrw*	Horus
ḳd	Horus	*ḳd*	Hapy	Children of Horus	*ḳd*	Imseti, Hapy, Kebehsenuf, Duamutef
sꜣwy ḳd	Hapy, Kebehsenuf	*sꜣwy ḳd*	Kebehsenuf	Hapy, Kebehsenuf	*sꜣwy ḳd*	Kebehsenuf, Hapy
ḫꜣw	Horus	*ḫꜣw*	Children of Horus	Children of Horus	*ḫꜣw*	Imseti, Hapy, Duamutef, Kebehsenuf
ꜥrt	Osiris	*ꜥrt*	Eye of Horus	Eye of Horus	*ꜥrt*	Eye of Horus
iwn sꜣḥ	Horus				*iwn sꜣḥ*	Horus
rmn ḥry sꜣḥ	Eye of Horus	*ḥry rmn sꜣḥ*	Children of Horus	Children of Horus	*rmn ḥry*	Eye of Horus
msḏr sꜣḥ	Eye of Horus				*msḏr sꜣḥ*	Children of Horus
rmn ẖry sꜣḥ	Eye of Horus	*ẖry rmn sꜣḥ*	Children of Horus	Children of Horus	*rmn ẖry sꜣḥ*	Eye of Horus
ꜥ sꜣḥ	Eye of Horus	*rmn sꜣḥ*	Eye of Horus		*ꜥ sꜣḥ*	Eye of Horus
sꜣḥ	Osiris	*sꜣḥ*	Osiris	Osiris	*sꜣḥ*	Osiris
spdt	Isis	*spdt*	Isis	Isis	*spdt*	Isis
siꜣt	-					
ḥr-wpš-tꜣwy		*ḥr-tꜣš-tꜣwy*			*ḥr-tꜣš-tꜣwy*	
ḥr-kꜣ-pt		*ḥr-kꜣ-pt*			*ḥr-kꜣ-pt*	
ḥr-ꜣḫty		*ḥr-ꜣḫty*			*ḥr-ꜣḫty*	
štwy	-	*štwy*	Hapy, Duamutef	Hapy, Duamutef	*štwy*	Duamutef, Hapy
siꜣtw	-					
nsrw	Imseti	*nsrw*	Imseti	Imseti	*nsrw*	Imseti
šspt	Eyes	*šspt*	Eye of Horus	Eye of Horus	*šspt*	Eyes of Horus
nhs	Horus					
		ipds	-	Horus	*ipḏs*	Horus
sbšsn	Horus	*sbšsn*	Horus	Horus	*sbšsn*	Horus
nṯr wꜣs	Duamutef	*nṯr wꜣs*	Duamutef	Duamutef	*nṯr wꜣs*	Duamutef
sbg		*sbg*			*sbgw*	
ḏꜣ		*ḏꜣ*			*sbꜣ-ḏꜣ*	

Table 50: Deities of the decans

These deities are clearly not randomly assigned, but the thinking behind their distribution is not clear. Neugebauer and Parker treat them as objects of curiosity, without remarking that some kind of logical purpose or process must have caused the associations. We have seen in the *Book of the Day* how an initially random-looking crew of figures in a procession of barques, on closer inspection proved to be a carefully planned illustration of the transformation of attributes of the retinue of the sun, some having clear meaning, such as the personifications of the steering oars, while others remain obscure to us but are nonetheless all part of an ordered scheme. In view of the observational origins of the decan lists, and the inclusion in the celestial diagrams of new observational data in the form of the number of stars (which we accept as an attempt at recording attributes of the decans), it appears likely that the decanal deities are not simply spiritual metaphors or mythical personifications of the decans, but present some kind of information for which we at present unable to supply a meaning.[205]

The Origin of Celestial Diagrams

We have already discussed the layout of the Nut vignette contained within the *Book of Nut* in the previous section. We saw how the diagram displayed temporal and positional information within a two-dimensional space, and how the cyclical elements of the motions of celestial bodies were treated.

The arched figure of Nut occurs in far more texts than those we have examined in this study. She is the goddess of the sky, and is often present on ceilings and the inner surface of coffin and sarcophagus lids.[206,207] A motif present on temple and tomb ceilings from the Old

[205] It is interesting to note that the gods of the Ennead plus Horus and his four sons are associated with the fourteen fingers of a half royal cubit (for an illustrated example see fig. 22.1 of Gillings *Mathematics in the time of the Pharaohs*). The other half of the cubit contains fingers associated with some of the circumpolar deities.

[206] Kozloff 'Star gazing in ancient Egypt' likens the stretched out form of the goddess to the 'swimming girl' type of spoon. She also however naively attacks Neugebauer and Parker for 'looking at the wrong sky' (i.e.

Kingdom through to the latest Ptolemaic temples was the repeating design of five-pointed yellow stars (often with a central red circle) on a dark blue background. These designs, while not individually forming part of this study, indicate the ancient basis and significance of the association of astronomical images and texts with the sky. In each case, the decoration not only depicts but also represents and takes on the attributes of the sky itself, in a relationship far more spiritual and significant than any modern star chart.[208]

Egyptian formal architecture is full of symbolism, mimicry of nature, and journeys through time and space. Decoration forms an integral element of the overall design, with surfaces used to show objects and events which have occurred, will occur, and must keep occurring in a cyclical eternity. The repeating star pattern indicated that the ceiling was the sky of the temple.

By the beginning of the New Kingdom, the repeating star pattern as an indication of the sky was improved, or specialised, into the celestial diagram in certain mortuary monuments. This transformation seems logically to be a development of the practice of using a diagonal star clock table on the inner surface of wooden coffin lids, but a gap of around 500 years between the last surviving diagonal star clock on a coffin and the first surviving celestial diagram in a tomb leaves a gap in our understanding of what sort of development occurred. One source which indicates that the link between diagonal star clocks and celestial diagrams occurred at the earlier end of this missing period is the coffin of Heny[209] from Asyut which

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they nowhere explicitly state that they have considered the effects of precession) in fact since they had no intention of identifying Egyptian celestial objects, their analysis did not rely on precession. Her own theory that Nut represents the Milky Way seems to be based on her desire to find a metaphor for the Milky Way in Egyptian texts. She seems unaware that there are many other candidates than the sky goddess herself, and clearly misunderstands the relationship between Nut and Geb.

[207] For a discussion of the relationship of Nut to the coffin, see Willems *Chests of life* pp. 133-136.

[208] Describing the decoration of coffins, Willems (*Chests of life* p. 242) states that 'the coffin is turned into a microcosm of the universe'. A similar process is of course at work in the decoration of temples.

[209] *Egyptian Astronomical Texts* 3 pp. 8-10.

probably dates from the XIth dynasty. This coffin (now perished) is therefore contemporary with the later diagonal star clocks. One fragment[210] contained readable labels for the figures of the circumpolar group and the names of some circumpolar deities. It is probable, from the inclusion of the names of decanal deities on another fragment, that the decans were also present. Some traces of the name of Jupiter were also visible.

The four elements decans, planets, circumpolar figures, and circumpolar deities, are the usual constituents of a celestial diagram, and were therefore associated at least as far back as 2000 BC.

Our next surviving source, H1 (the ceiling of the tomb of Senmut), sets a pattern for celestial diagrams to the end of the New Kingdom and beyond. The layout is broadly the same throughout the New Kingdom, and there continues to be a strong link with timekeeping. In the case of H1, H2, H5, H9, and H10, the lunar months or lunar feasts were included. H2 occurs on a timekeeping instrument and H11 to H16 occur in association with the Ramesside star clock tables. This link shows that the sky was, during this period in Egyptian history, considered to be both the source and the indication of the passage of time.

The figure of Nut appears, as we have seen, in the *Book of Nut* and in the *Book of the Day* and *Book of the Night*. The figure also occurs as a frame for parts of the celestial diagrams in H15, the tomb of Ramesses VII.[211] Elements of the *Book of the Night* occur in the celestial diagram in the tomb of Ramesses IX.[212] These links tie together the sources we have discussed into a group of closely related texts. Each text describes or illustrates some part of the Egyptian sky.

These texts lead us to formulate a model of the Egyptian perception of the movements of the same celestial bodies that we see today.

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[210] Battiscombe Gunn "The Coffins of Heny".
[211] *Egyptian Astronomical Texts* 3 p. 34.
[212] *Egyptian Astronomical Texts* 3 p. 37.

Division of the Sky

The celestial diagrams and astronomical texts that we have considered so far show that certain parts of the sky were given greater prominence than others. The diagrams contain little in the way of reference for the observer, such as an indication of the horizon, and in this sense resemble modern star charts rather than instruments such as planispheres and planetariums which show star positions relative to the observer's horizon at a particular time and location.

The elements which are included are divided strictly into groups. Differences in layout do not alter the individual nature of the groups. We have the circumpolar figures and the accompanying circumpolar deities as one unit, the main decans, five planets, and triangle decans as another unit, and the lunar months and Ramesside star clock tables as two optional units. These component parts never intermingle, and within each unit orders are strictly preserved: the circumpolar deities (barring omissions) always appear in the same order.[213] The only exception is the location of the label or figure of the goddess Isis which is always located behind the Hippo.[214] There is some confusion whether the label was originally intended to belong to the Hippo[215] implying that Isis as a member of the circumpolar deities is an intrusion. Equally rigorous in their arrangement are the two sets of decans and the two sets of planets: main decans are followed by the superior planets, then triangle decans, and finally the inferior planets. The internal order of the decan lists is disturbed by the practice of putting two decans in one column with the later decan placed above the earlier. There is also confusion in the area of Orion in some decan lists[216] and the triangle is never complete.

[213] These deities are listed in *Egyptian Astronomical Texts* 3 pp. 194-199. The depiction of circumpolar deities in H1 is given in detail in Dorman *The Tombs of Senenmut*.
[214] *Egyptian Astronomical Texts* 3 p. 194.
[215] *Egyptian Astronomical Texts* 3 p. 189.
[216] This is dealt with extensively in *Egyptian Astronomical Texts* 3 pp. 112-114.

This implies that by the time the decans were being used as part of celestial diagrams, the triangle was obsolete as a functional group of timekeeping stars, but was retained because, whether or not the names held any significance of their own, their existence in the overall picture was important.

The lunar month figures and Ramesside star clock tables had an order that was defined by date. It is interesting that the lunar months are the only representative of the moon that we see incorporated into the celestial diagrams. The baboon which appears in the centre of the third register (lunar months)[217] in the Ramesseum and Medinet Habu ceilings has been said to represent the intercalary lunar month Thoth,[218] and also was present above the jet of the Karnak water-clock. The water-clock also contains a vignette depicting the sun and the moon in the form of the figures of Re-Horakhty and Iah, the only direct allusion to these two bodies associated with a New Kingdom celestial diagram.

We noted earlier the cyclical nature of the Nut vignette from the *Book of Nut* in relation to both spatial and temporal considerations. The water-clock displays essentially the same layout as the Ramesseum and Medinet Habu ceilings mapped on to a truncated conical surface. The inclusion of the civil calendar months running along the top of this layout, together with the months or festivals of the lunar year on the third register reinforce the idea that this diagram is cyclical, or even cylindrical in essence. This idea fits with the notion of a loosely defined 'decanal belt' and the path of the planets that we now define as the ecliptic. The rigid distinction between the circumpolar stars and the decans leads us to take this cylindrical notion one stage further and to imagine the sky as a cylinder capped by a circular circumpolar region.

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[217] Or representations of the festivals of the lunar month if Clagett (*Calendars, Clocks, and Astronomy* p. 22) is right in discounting Parker's assertion (*Calendars* p. 43) that the lunar months are portrayed here.
[218] Parker *Calendars* p. 43.

This cylinder is a conceptual model derived from what we have learned from the celestial diagrams that we can use to visualise the Egyptian sky. It must be stressed that the model is not in any way intended to be used as a basis for a co-ordinate system or for geometrical analysis of any kind, nor is it supposed that the Egyptians ever used a three-dimensional figure like a cylinder for this purpose. Such a model is useful because it allows us to discard some modern preconceptions such as 'the celestial sphere' which, despite their wide acceptance now, are not universal physical truths. It allows us to label different areas of the sky and to distinguish them in a general sense without needing to quantify our theories in terms of relationships with our own astronomical tools: the meridian, the ecliptic, the alt-azimuth grid etc.

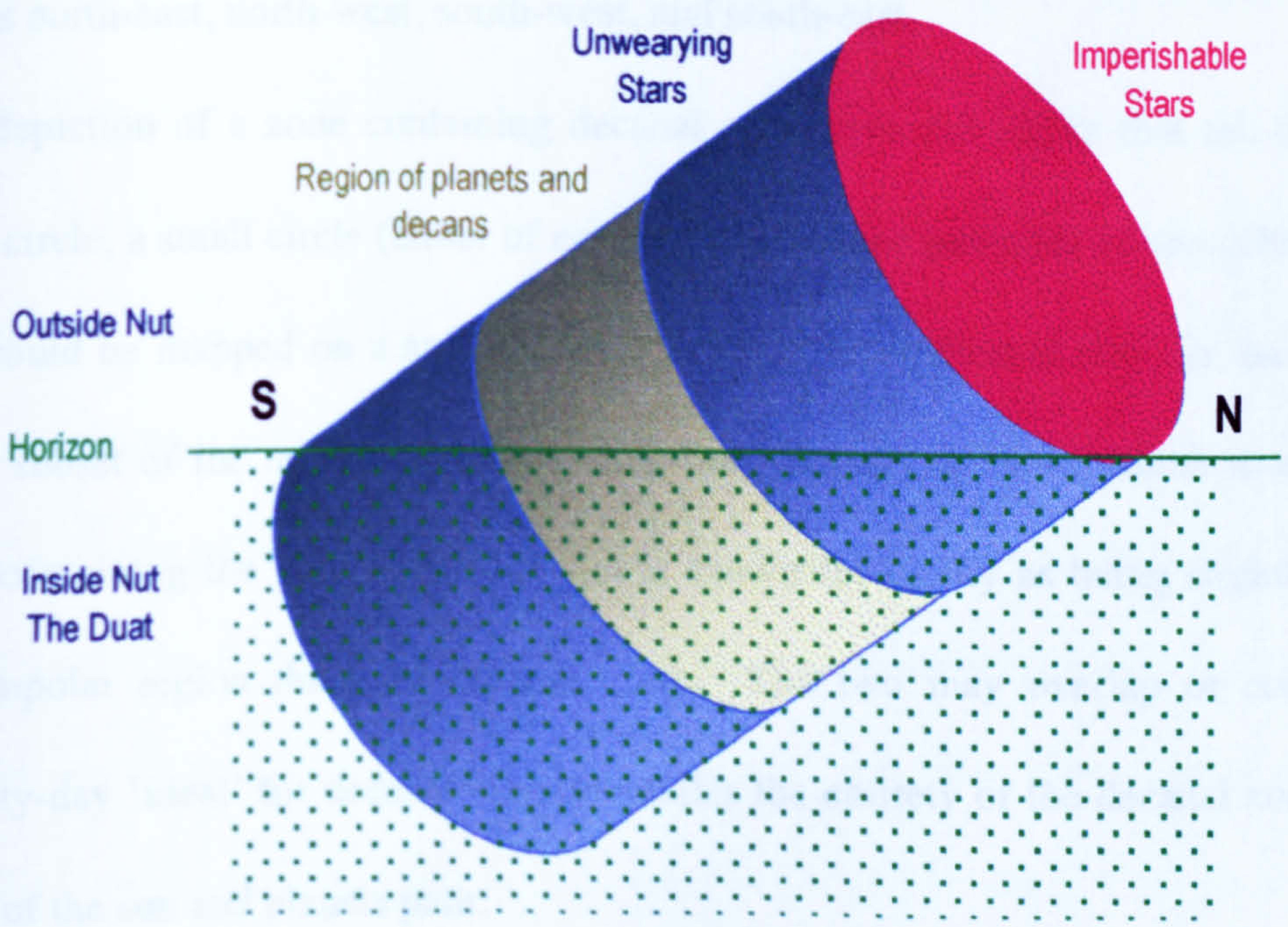

Figure 32: Conceptual model of the Egyptian sky

The model is illustrated in Figure 32. The cylinder rotates around its axis representing the apparent rotation of the sky about the circumpolar region. No particular point is distinguished as the point of rotation 'the North Celestial Pole', but the circumpolar area containing the circumpolar group is clearly defined.

The continuation of the cylinder's surface below the horizon reflects the dramatic text's indication that the stars were still moving after they had set, and indeed were still moving through the sky (on Nut's body) even when they were invisible due to the brightness of the sun. We know that the horizon was very important in religious literature. We also know that it was in the region of the horizon that the most important astronomical events took place: sunrise, sunset, heliacal rise, and heliacal set. We must also note that the texts and the events listed above lead us to the conclusion that the horizon must be visualised as a region rather than a line (the 'ideal horizon' of modern positional astronomy). We know that the horizon was referred to using the cardinal points in order to distinguish probably at most eight different general regions relating to the four cardinal points and the four intermediate points north-east, north-west, south-west, and south-east.

The depiction of a zone containing decanal stars does not imply that the decans lay on a great circle, a small circle (either of equal declination or inclined) or any other line or region that could be mapped on a sphere. Here, it is simply indicated that the decanal stars were some subset of the non-circumpolar stars, the Unwearying Stars which rose and set. The zone containing the planets and the sun is shown for clarity as being slightly closer to the circumpolar region than the decanal zone. The two may overlap or coincide, but the seventy-day 'ideal' for decanal stars precludes the entirety of the decanal zone being to the north of the sun and planets path.

No evidence has been found for the existence of 'the ecliptic' or 'the obliquity of the ecliptic' as formal concepts in New Kingdom Egypt. The inclusion of the planets in decan lists in celestial diagrams and the description of the decans being 'in the entourage' of the sun gives the impression that the tightest definition of the path of the sun and the planets was that they and the decans were in a similar region of the sky.

Identification of the Egyptian Stars

It has become customary to close any work on stellar timekeeping with a proposal of a system identifying certain Egyptian stars with our modern constellations or individual stars. Neugebauer and Parker throughout *Egyptian Astronomical Texts* stated that Egyptian texts did not hold enough information of a positional nature to make such identifications possible, but many researchers have extracted enough to propose theories.

It has already been noted that various identifications for the Egyptian circumpolar group have been proposed, yet there is even less information about the Egyptian circumpolar group than about the decans and the hour stars. Even the definition of the circumpolar area is controversial, with Wainwright[219] placing figures from the group well beyond the limits of the astronomical circumpolar region viewed from Egypt in dynastic times. No identifications have been widely accepted.

There has been some controversy concerning the nature of the 'decanal belt' between two possibilities: a region to the south of (and tracing the shape of) the ecliptic, and a band of equal declination south of the celestial equator. To a large extent, this controversy is manufactured by those who wish to promote various schemes of star identifications. There is nothing in the diagonal star clocks which suggests that decans form a 'belt' or were chosen (as we saw in Section D) with any positional factors other than ease of observation and identification in mind. The motive suggested in Section D was of a temporal nature, as have been other theories for the motive for the construction of star clocks.

Locher disputed Neugebauer and Parker's method of locating the 'decanal belt': 'There is a sample of interrelated texts roughly one thousand years later than the diagonal star clocks, whose best known example is Papyrus Carlsberg [*sic*], and whose crucial astronomical statement ascribes a 70-day annual

[219] Wainwright 'A pair of constellations'.

invisibility to *all* the 36 decans. Neugebauer and Parker did not doubt this statement despite the 1000-year gap between the star clocks and the papyrus, and so they concluded that the belt runs roughly parallel to the ecliptic.'[220] However, his argument is difficult to interpret. We have seen that the surviving diagonal star clocks were compiled and painted around 2000 BC. The seventy-day period mentioned in Papyri Carlsberg 1 and 1a is also explicitly present in the New Kingdom versions of the *Book of Nut* in the form of the date list (which is not present in either of the Papyri) and would appear to date from 1850 BC.[221] In the *Book of Nut*, the date list is associated with decans which appear in the diagonal star clocks. This shows that Neugebauer and Parker's 'assumption' was more firmly based than Locher suggests.

Locher had previously presented[222] a collection of identifications for Egyptian decanal constellations which lie on a belt of equal declination. Locher believes that the sequence of labels present in several astronomical ceilings 3-*nwt ḫt*, 4-*nwt ḫt*, 5-*nwt ḫt*, 6-*nwt ḫt* does not indicate (as is generally thought) 'third cluster, fourth cluster, fifth cluster, sixth cluster', but instead refers to the number of stars within a cluster (i.e. 'a cluster of three, a cluster of four, a cluster of five, a cluster of six') which seems very unlikely indeed. Yet this is the basis of his identification of a group of five stars in a 'lemonpip' shape as being represented by a figure present in the ceiling from the tomb of Senmut (H1, see Figure 31), and <u>hence</u> that the decanal belt is parallel to the equator.

He has not so far revealed his methods of identifying other stars beyond remarking that they are 'based mainly on figurative considerations and agreement in right ascension'.[223] The former reason is clearly illustrated by his conviction that certain stars form the image of a sheep, and that others can be joined by lines to resemble an inverted version of the Sothis and Sahu figures

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[220] Locher 'Two further coffin lids'.
[221] See Section D.
[222] Locher 'New arguments for the celestial location of the decanal belt'.
[223] Locher 'Two further coffin lids'.

in the vertical strips of diagonal star clocks. The latter reason is weak due to the decans originally, and perhaps always, being observed near the horizon which does not trace a line of equal right ascension on the celestial sphere. Neugebauer and Parker[224] modelled the risings of decans by a series of great circles or 'horizons', yet the physical realities of near-horizon observation[225] mean that their model can only be used (as they surely intended) as a conceptual scheme and not as a definitive tool to produce positive identifications.

Böker, in his attempt to identify decans, relinquished the idea of a 'belt' in favour of a system based on the right ascension of the culminating moon. His conclusions, collated and published after his death in 'Über Namen und Identifizierung der ägyptischen Dekane', are presented without a full discussion of his methods. His list of identifications draws heavily on later information, and by parallels with other cultures' naming of stars. Again, his proposals have not been accepted and have been criticised by other researchers in their own attempts towards identifications.

Leitz's work on the hour stars has already been extensively discussed in Section C. He arrives at possible identifications as a natural conclusion of his analysis methods, and as such, presents the most strongly argued case for stellar identification. Yet he himself admits that his identifications cannot be accepted as certain, or even probable.

Until enough evidence is gathered to create some consensus of opinion on any identifications other than Orion, Sirius, and The Plough Neugebauer and Parker's assertion that the Egyptian stars will remain unknown will stand. The conceptual model presented above offers no solution to the identification problem, indeed the removal of the spherical co-ordinate frame of reference places such a solution even further from our grasp, but this is balanced by the increased freedom from assumptions that the model encourages.

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224 *Egyptian Astronomical Texts* 1 pp. 97-107.

225 Schaefer 'Refraction near the horizon', 'Heliacal rise phenomena', 'Extinction angles' etc.

CONCLUSION

We have examined minutely timekeeping methods, some based on familiar concepts and others alien to us, and have also briefly examined a wider perspective of the composition of the sky. Both areas form part of our understanding of the extent to which the ancient Egyptians were interested in the sky. In the course of this study, it has been demonstrated that preconceptions of methodology, motives, aims, and priorities form a barrier between the modern mind and the ancient sources. In the case of the 'transit star clock', these preconceptions have led an assumption to become a generally accepted, previously unchallenged theory. In the case of the Ramesside star clock, one hundred years of sporadic discussion has produced a theory of usage almost by default, which certainly deserves closer inspection. A new theory has been offered which demonstrates that the subject cannot yet be considered closed. Further study of the Ramesside star clock tables is now aided by the ease of analysis using computers which were not available to earlier researchers. The use of such methods to test hypotheses and to find trends within the original data in the present study has indicated that further information may be gained in this way in the future.

In the section concerning the development of stellar timekeeping methods, this new approach was incorporated into a survey of types of star clock. A possible series of events which established the decans as a persistent group in Egyptian cosmography, and which may have produced many more variants of stellar timekeeping methods than have survived, has been outlined and discussed. We saw that this process may well have been a simpler but longer course of development than the widely accepted but rarely stated 'flash of genius' scenario in which the first diagonal star clock sprang fully-formed from the mind of its single inventor. The gradual development of such a complex method is intrinsically more likely, but has appealed more to those meeting the tables for the first time than to those who study them professionally. Perhaps this is because the complexity of the tables which is obvious to the unprepared mind is lost to researchers who habitually deal with the formulae and order of modern mathematical astronomy.

During the discussion of each timekeeping method, including the familiar concept of shadow length, we have also faced the difficulty of accepting a different notion of time itself. That is, that the makers and users of instruments had a set of priorities which differ considerably from our own. Nowadays, 'time' is a measuring stick for recording the order and relative length of events. It has, as a concept, an existence and integrity of its own.

Egyptian 'time' is different. 'Time' as a steady, measurable, and abstract flow did not exist in the Egyptian world picture. The Nile rose when it did, Sirius appeared when it did and the sun rose when its battles during the night had been completed. This self-referential nature of time is incredibly difficult for us to grasp fully, as is the recurrent Egyptian notion that there are two types of 'time' in the sense of two types of eternity. Commonly, the king was said to be given life like the god Re for ever and ever. 'Ever and ever' is a common phrase in the English language (used in a similar context in the Lord's Prayer, for example) repeating the word 'ever' for emphasis. However, this is a weak translation of the Egyptian phrase which in fact uses two different words *ḏt* and *nḥḥ*, that is, linear eternity and cyclical eternity respectively. It is the later concept, cyclical time, which relates to the timekeeping devices we have discussed.

As an aside, we can perhaps draw a parallel between the cyclical time, which the star clocks measured and which the Egyptians surely would originally have thought of as eternal and never changing, and the linear time, which we can liken to the slow creep due to the year length or the almost imperceptible change wrought by precession that together conspired both to frustrate the Egyptians' attempts at temporal stability and to provide the modern researcher with tools for analysis and dating.

Returning to the Egyptian viewpoint, the passing of 'time' would only be seen in the occurrence of events, and if these events occurred at intervals which seem ill-defined or irregular to us, then that is a problem with our perception, not a question of 'inaccuracy' in ancient methods. The implication of this approach to our analysis of timekeeping instruments is that each instrument must be allowed to define time, not just measure it.

It seems that 'hours' were initially divisions of the night in the same sense that 'gates' and 'caverns' were divisions of the Duat. They presented a time framework for the events which occurred to the sun in his nightly voyage through the Duat, and by extension, the journey of the deceased after death. This connection between night-time events and the dead is apparent throughout the *Pyramid Texts,* and continues to hold throughout the New Kingdom. All our sources for stellar timekeeping and astronomical diagrams come from objects or locations associated with the dead (with the one exception of the Karnak water-clock). Although the survival rate for funerary objects and texts is higher than that associated with items everyday life, the connection can be shown to be valid by the instances of astronomical ceilings in mortuary temples where their east-bank 'living' temples show only repeating star patterns.

It is only in the New Kingdom that we have clear evidence that the formal night 'hour' concept was applied to the daylight hours. Of course, it is not suggested that no daylight time divisions existed until the New Kingdom for use in daily life. *Ad hoc* sundials, water-clocks, and wicks would all serve to measure some repeatable time period sufficient to time working shifts.

With the collection of sources we now have, we therefore judge that timekeeping during the night using stars was clearly a ritual procedure. We also must agree that logically, timekeeping in the dark has little conceivably practical purpose. This completely divides the Egyptian perception of the night hours from our modern idea that all 'hours' are of the same, abstract nature. The Egyptian train of thought would not naturally progress from the motivation of ritual to thoughts of standardisation and of accuracy which we automatically associate with the word 'clock'. Releasing the instruments from the duty of measuring accurately an external unit has massive repercussions on the study of Egyptian timekeeping. In the past, each study of a newly discovered method has begun by asking: 'How does this instrument measure hours and how accurate is it?' If modern hours are completely removed from the initial investigation, each timekeeping method can be approached by first determining the relationship between the instrument and the reference it used (for example the stars, the sun) and learning as much as possible about that relationship. Only after all primary information has been gathered, including context and related texts, should the question be asked: 'What was the nature of the time periods marked by this device?' Questions of accuracy are irrelevant until the very last stages of investigation because 'accuracy' requires the intrusion of modern parameters that can colour the perception of the instrument radically and lead to conclusions that are inappropriate.

Each researcher in this field has a duty to look first at the Egyptian sources, and to respect at all times that, despite copying errors, damage, and confusion, the contemporary information must always supersede modern intrusive operational parameters.

This study has attempted to follow these precepts as closely as possible. Using the basic facts thus gathered, new theories have been presented which offer an alternative or improved understanding of the ancient methods and concepts. It is hoped that such work will provide a basis for future discussion of the subject areas covered. Two areas which may yield further results are clear: the Ramesside star clock and the field of astronomical vocabulary in religious literature. The former has already been mentioned, while the latter area was touched on during research towards this study, and proved to be a huge but potentially rewarding undertaking, linking the subjects of Egyptian astronomy, linguistics, and religion. It is hoped that with continued research, improved methodology, and new sources, the two areas of timekeeping and cosmography will continue to add to our understanding of the development of human scientific thought, and that this study has contributed to that process.

APPENDIX

Chronology (after Baines and Malek *Atlas of Ancient Egypt*)

Late Predynastic	c. 3000 BC	
Early Dynastic	2920-2575 BC	Ist to IIIrd Dynasty
Old Kingdom	2575-2134 BC	IVth to VIIIth Dynasty
1st Intermediate Period	2134-2040 BC	IXth to XIth Dynasty
Middle Kingdom	2040-1640 BC	XIth to XIVth Dynasty
2nd Intermediate Period	1640-1532 BC	XVth to XVIIth Dynasty
New Kingdom	1550-1070 BC	XVIIIth to XXth Dynasty
3rd Intermediate Period	1070-712 BC	XXIst to XXVth Dynasty
Late Period	712-332 BC	XXVth to XXXIst Dynasty
Greco-Roman	332 BC – AD 395	Macedonian, Ptolemaic, Roman

The New Kingdom

	Aamose	1550-1525
	Amenhotep I	1525-1504
	Djehutymes I	1504-1492
	Djehutymes II	1492-1479
	Djehutymes III	1479-1425
XVIIIth Dynasty	Hatshepsut	1473-1458
	Amenhotep II	1427-1401
1550-1307	Djehutymes IV	1401-1391
	Amenhotep III	1391-1353
	Amenhotep IV (Akhenaton)	1353-1335
	Smenkhkare	1335-1333
	Tutankhamun	1333-1323
	Ay	1323-1319
	Horemheb	1319-1307
	Ramesses I	1307-1306
	Seti I	1306-1290
XIXth Dynasty	Ramesses II	1290-1224
	Merneptah	1224-1214
1307-1196	Amenmes	1214-1210
	Seti II	1210-1204
	Siptah	1204-1198
	Twosret	1198-1196
	Setnakht	1196-1194
	Ramesses III	1194-1163
	Ramesses IV	1163-1156
XXth Dynasty	Ramesses V	1156-1151
	Ramesses VI	1151-1143
1196-1070	Ramesses VII	1143-1136
	Ramesses VIII	1136-1131
	Ramesses IX	1131-1112
	Ramesses X	1112-1100
	Ramesses XI	1100-1070

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Index of Abbreviations in the Bibliography

ÄA	*Ägyptologische Abhandlungen*, Wiesbaden
Acts 6th ICE	*Sesto Congresso Internazionale di Egittologia, Atti*, Turin
AE	*Ancient Egypt and the East*, London
ASAE	*Annales du service des antiquités de l'Égypte*, Cairo
BEES	*Egyptian Archaeology: The Bulletin of the Egypt Exploration Society*, London
BiOr	*Bibliotheca Orientalis*, Leiden
BIE	*Bulletin de l'Institut d'Égypte*, Cairo
BIFAO	*Bulletin de l'Institut Français d'Archéologie Orientale*, Cairo
BMMA	*Bulletin of the Metropolitan Museum of Art*, New York
CdE	*Chronique d'Égypte: Bulletin Pério dique de la Fondation Égyptologique Reine Elisabeth*, Brussels
JARCE	*Journal of the American Research Center in Egypt*, Boston
JAS	*Journal of Archaeological Science*, London
JBAA	*Journal of the British Astronomical Association*, London
JEA	*Journal of Egyptian Archaeology*, London
JHA	*Journal for the History of Astronomy*, Chalfont St Giles
JNES	*Journal of Near Eastern Studies*, Chicago
MIFAO	*Mémoires Publiés par les Membres de l'Institut Français d'Archéologie Orientale du Caire*, Cairo
Proc 7th ICE	*Proceedings of the Seventh International Congress of Egyptologists 1995*, Cambridge
RecTrav	*Recueil de travaux rélatifs à la philologie et à l'archéologie égyptiennes et assyriennes*, Paris
SAK	*Studien zur Altägyptischen Kultur*, Hamburg
SAOC	*Studies in Ancient Oriental Civilisation*, Chicago
ZÄS	*Zeitschrift für Ägyptische Sprache und Altertumskunde*, Leipzig

TABLES

FIGURES